STREAM

INVENTORY

HANDBOOK

Version 3.001

7/14/89

STREAM

INVENTORY

HANDBOOK

Version 3.001

7/14/89

CHAPTER 2

Stream Inventory Handbook

APPENDICES

210 LEVEL I - IDENTIFICATION LEVEL - OFFICE PHASE

210.1 - Requirement/Objectives. The objective of the office phase is to provide the field crews with a general introduction to the stream system targeted for survey. This is accomplished through assembly and summarization of any data that has been previously collected for the basin. This information will be used to tentatively stratify the stream system into stream order and stream reach. A reach is a relatively homogeneous section of stream that contains attributes of common character. Review of the information compiled by the office phase will be extremely valuable in selecting sampling intervals using Hankin/Reeves methods, planning stream access logistics, summarizing initial hydrologic information, and initially identifying perennial and fish-bearing streams.

Photo analysis and use of maps of suitable scale e.g. 4 inches = 1 mile/ 1:15,840, will enable the survey team to identify with some accuracy such attributes as: sinuosity, vegetative types in riparian and upslope areas, watershed acres, valley bottom widths, tributary confluences, and watershed characteristics. The maps created during this process will be of great value to the field crews who survey the watershed more intensively at a later date. An effective field map(s) will show tributary streams, road crossings, access points, and general location of notable geologic features, and unique characteristics. These parameters will be used by the field crew to accurately locate reach breaks and features in the basin.

210.2 - Standards. The office phase survey will provide information only as accurate as the scale and accuracy of the maps, photos and previously collected data. Accuracy will also be affected by the human error introduced when measuring the attributes required. At a minimum, use 1:15,840 scale USGS topographic maps. Any measurements should be confirmed with a map wheel, dot grid, or other standard method of measurement.

210.3 - Equipment Needed.

Topographic Maps/Aerial Photos - Scale of 4 inch to the mile preferred.
Planimeter/Map Wheel
Calculator
Watershed Codes from FSH 2509.24
Hydrological Data - flow, temperature, turbidity, stream class, macroinvertebrate, etc.
Geological Information - Geological province, landform type, etc.
Past Stream Surveys - Measured length of reaches, pool/riffle/glide ratios, etc.
Level I - Office Phase Form
- Form A - Stream Identification Form
- Form B1 - Preliminary Reach Identification Form

Canopy cover template

210.4 - Procedure. The office phase requires the completion of Forms A and B1. Much of information for Form B1 can be collected from the aerial photos and topographic maps. **PLEASE NOTE THAT THE INSTRUCTIONS FOR COMPLETING THE HEADER FOR EACH FORM ARE LISTED ONLY IN FORM "A" INSTRUCTIONS. ATTRIBUTES 1 THROUGH 7 ARE THE SAME FOR EACH FORM.**

OFFICE DATA ENTRY INSTRUCTIONS:
STREAM IDENTIFICATION - FORM A, R6-2500/2600-10.

Fill out a Form A for each stream:

ATTRIBUTE	MEASUREMENTS/RECORDING
1. State	Enter the appropriate code: Oregon 41 Washington 53 California 06 (Field Length [FL]:2 characters)
2. County	Record county in which stream is located by FLUR code. Refer to Forest Land Use Report, User's Guide. (FL:2)
3. Forest	Enter appropriate two digit code for the Forest. (FL:2)
4. District	Enter appropriate two digit code for District. (FL:2)
5. Stream Name	Enter name of stream as shown on USGS quad limiting the length of the name to 25 characters. (FL:25)
6. Watershed/Stream	Refer to FSH 2509.24 for 6 field code which codes stream to specific NFS watershed. Include 6th field alphabet code for subdrainage if identified on your Forest. (FL:6)
7. Forest Name	Enter the Forest Name limiting the name to 25 characters.
8. Team	Record the name of the person(s) who assembled the data for this stream; use DG format, first initial and last name. Underline the person filling out the form.

(THE HEADER ATTRIBUTES LISTED ABOVE WILL BE THE SAME FOR EACH FORM)

9. USGS Quad	Enter the name of the registered USGS 1/2 Quad containing the stream mouth or point where it leaves the Forest. This is the 1:15,840 or 4 inch to the mile map base used in TRI. (FL:26)
10. Stream Order	Utilizing the Strahler method (Appendix A), identify stream order. A 1st order stream is any identified streamcourse and will show as either a solid or dashed line on the map. (FL:2)
11. Watershed Area	Calculate the area of the basin above the mouth or above the point where the stream leaves the Forest to the nearest 250 acres (100 hectares). This measurement may be easier to attain using a map scale of 1" = 1 mile. (FL:6)

12. Stream Class	Designate the stream class of the stream(s) to be surveyed (e.g. Class I,II,III, IV or V. See FSM 2526 or TRI Aquatic subsystem.) If not available, leave blank. (FL:3)
13. Fish Species	Starting from the left, record dominant or management emphasis fish species known to be in the basin. See Appendix B for species abbreviations. Enter a maximum of four codes. Write the source of the information in the space provided. (FL:8)
14. Flow Data	If flow data is available enter Y for yes. If no flow data is available enter N for no. Reference the source of the information and year collected. (FL:1)
15. Water Quality Data	Enter Y if available, N if not available. Review files for any quantitative physical or chemical data. Reference the source of the information and year collected. (FL:1)
16. Macroinvertebrate Data	Enter Y if available, N if not available. Reference the source of the information and year collected. (FL:1)
17. Previous Surveys	Enter Y if available, N if not available. Reference the source of the information, level of survey and year accomplished. (FL:1)
18. Historical Land Use Data	Record here any useful historical information you may have regarding the stream (e.g. old photos, interviews on file, splash dams, mining, literature, etc.). Also review the Forest's Historical Land Use Atlas -- see an Archeologist for this document.
19. Comments	Use this space to elaborate on the above attributes. Note apparent watershed problems, special features or habitats, fish stocking information, management problems, studies, critical habitats, special land allocations, etc.

OFFICE DATA ENTRY INSTRUCTIONS:
PRELIMINARY REACH IDENTIFICATION - FORM B1, R6-2500/2600-20

This form will incorporate much of the data completed in Form A, but will break the stream system into preliminary homogeneous stream reaches necessary for selecting sampling intervals and summarizing, interpreting, and reporting information. Reach characteristics which should be used to select stream reach breaks are: valley form and valley width (Appendix C), relative gradient changes, channel form changes, stream order (tributary confluences), sinuosity, and flow changes.
The field crew will verify the initial reach breaks and locate them accurately on a field map/photo. This form serves as a "tickler list" in identifying potential reach breaks; actual delineation will occur on the ground. At times, not all of the parameters listed on this form will be used to identify reach breaks.

Fill out a Form B1 for each stream reach:

(NOTE INSTRUCTIONS FOR ATTRIBUTES 1 - 8 ARE LISTED IN FORM A INSTRUCTIONS):

ATTRIBUTES	MEASUREMENTS/RECORDING
9. Reach Number and River Mile	Enter the reach number beginning at the lowest point of the proposed survey, number the reaches sequentially upstream. Enter river mile as it corresponds to the starting and ending points of the reach to the nearest 0.1 miles.
10. Valley Form	Enter appropriate code that best describes the valley form. Examples are: Wide, glaciated U shaped Valley; Steep, narrow V shaped valley; Broad, flat plain; Alluvial outwash; etc. (See Appendix C).
11. Valley Width Class	Enter the code which best describes the valley width. See Appendix C for illustrations. 1= <30 meters (<100ft.), 2= 30m-100m (100-300ft.) 3= 100m-200m (300-600ft.) 4= >200m (>600ft.) (FL:1)
12. Flow Regime Changes	Note any large tributaries that originate in watersheds of large or similar size to the proposed surveyed watershed. Reaches can be stratified by significant changes in flow, while other variables remain the same. Enter yes Y or no N.
13. Channel Sinuosity	Note whether: Straight - no bends or meanders; Low - slight meandering occurs, but channel is generally confined by the side slopes. Moderate - meanders and bends apparent from topographic map or photos, not much valley confinement; and High - bends and meanders abundant, little to no valley confinement. These categories are intentionally plastic to allow for regional and unit variation. IT IS MORE IMPORTANT TO NOTE CHANGES OF SINUOSITY WITHIN A BASIN, THAN TO COMPARE SINUOSITY BETWEEN BASINS (for the purpose of this form). See Appendix D for diagrams.

14. Average Channel Gradient — Note GROSS changes in gradient of the presumed channel reach breaks. Long homogeneous lengths of similar gradient may delineate a reach. However, the other observed parameters can temper the stratification. Gradient can be calculated by dividing the elevation gain (high elevation contour minus low elevation contour) by the lineal distance of stream.

15. Stream Shade — Enter the average percentage of the stream that is shaded from any source (vegetation, topography, etc.) in the following categories:

1. 0 - 19%
2. 20 - 30 %
3. 31 - 60%
4. + 60%

This may be determined <u>either</u> in the office from canopy cover templates on aerial photo <u>and/or</u> in the field. Be sure to place appropriate code on form B2, following field verification.

16. Other — Note any other criteria that you used to help make the reach stratification.

17. General Comments — Write down any comments important to the aquatic/riparian resources. Good place to clarify some of the entries made above.

210.5 - <u>Outputs</u>. The Identification Level/Office Phase generates information for Forms A and B1. The information from Form A will be used along with Form B2 (field reach verification form) to complete one of several data summary tables. Information from Form B1 will be used to complete Form B2; once Form B2 has been completed, Form B1 is no longer needed.

R. Howard

220 - LEVEL II - RIPARIAN INVENTORY - FIELD PHASE

220.1 - Requirement. The Level II survey is the basic habitat inventory for determining the quality and quantity of fish habitat, and to obtain basic riparian and hydrologic condition. The objective of the Level II survey is to provide generally quantitative characterization of aquatic (fish/water) and riparian conditions at a watershed scale.

220.2 - Standards. Standards for the Field Phase are intended to obtain quantitative data. Specific standards for the procedure to accomplish the Field Phase are listed below. Data collected in the survey shall be at least as accurate as specified and all parameters listed will be included in the survey.

1. It is paramount that once a Forest starts a survey that they continue collecting the data in the same units - either english or metric. The computer program will take either metric or english units but mixing units of measure is undesirable.

2. It is very important that the users of this handbook review and become familiar with the following paper: Hankin, D. and Reeves, G. 1988. Use of Visual Methods for Estimating Fish Abundance and Habitat Areas in Small Streams. This paper is a field guide which defines the standards, techniques, and quality controls needed in order to properly implement a Hankin and Reeves fish survey. This paper is included as Appendix E.

3. It must be emphasized that the field crew member who does the visual estimates (caller) should continue to make the estimates at least through several stream reaches. **DO NOT CHANGE ESTIMATORS MID-WAY THROUGH A REACH! IF A CHANGE IN CALLERS IS NECESSARY, CHANGE AT THE START OF A NEW REACH BREAK!** This is paramount in establishing the correction factor for visual estimates vs actual measurements. People judge distances differently, and it is necessary that deviation from actual length be consistent.

4. A system of photographs shall be established for the stream reach. A representative section of the stream reach and any significant features of interest, special habitats, problem areas, etc. within the reach shall be photographically documented.

5. A working map will be developed during the office procedure that will facilitate and expedite the field procedures portion of the survey. This working map has been described in the 210.1 section of this manual. Field notes and observations shall be noted on this map, since this map will serve as the foundation for a final survey map to be included in the watershed analysis package.

220.3 - Equipment Needed.

Level II Survey Forms (R6-2600-? to R6-2600-? 6/89), as appropriate.
Mechanical pencils. clipboard.
Four (4) inch to a mile (1/2 quads, 1:15,840 scale) USGS quads as base maps.
USGS quads and aerial photographs.
50-meter (150 foot) tape measure.
Good quality, heavy duty scale stick.
Camera.

Water velocity meter or velocity headrod.
Thermometer.
Clinometer or abney level.
Plastic strip flagging and grease pencil/marker for use as needed.
Hip boots and felt or corkers.
First Aid kit.
Radio where needed.
Snorkel, mask, wetsuit, drysuit, electroshocker, and block nets.

220.4 - Procedure. There are three phases needed to complete a Level II survey: (1) preplanning before starting field work (see level I); (2) field measurements (field phase) which include reach location data and riparian data for every reach sampled (Form B2, C1 and C2, & D); and (3) data entry, analysis and summarization or reporting.

FIELD DATA ENTRY INSTRUCTIONS:
FINAL REACH IDENTIFICATION FORM B2, R6-2500/2600-21

The purpose of this form is to identify FINAL reach stratification for a given section of homogeneous channel. Several parameters on this form are similar to those found on FORM B1. However, additional variables are measured/observed in the field to support the refined delineation of the reach. Common parameters between the two forms are: valley form, valley width, flow regime change, and average reach gradient. Additional field data may include: channel entrenchment, stream shade, gradient, and dominant/subdominant substrate.

Parameters in this form should be collected while in the field. However, final reach delineation cannot be made until field data on Form C has been collected and initially evaluated. Reaches shall begin and stop on specific habitat units (e.g., pools, riffles, or glides) that have accompanying natural sequence numbers. After those terminal units have been identified, final reach stratification can occur. It is imperative to stop or start a reach in a habitat unit that can be specifically identified on the ground and is a permanent, fixed feature (waterfall, road crossing, cliff, etc.).

Following the field reach verification, total VALLEY length will be measured between the starting and ending points of the reach; this will allow a FINAL sinuosity value to be derived from the data. This value will be displayed in a summary table. Note that VALLEY LENGTH will be measured by map wheel in the office following completion of the field work.

Fill out a Form B2 For Each Stream Reach:

(NOTE INSTRUCTIONS FOR ATTRIBUTES 1 - 8 ARE LISTED IN FORM A INSTRUCTIONS):

ATTRIBUTE	MEASUREMENTS/RECORDINGS
9. Reach Number and River Mile	Enter the reach number beginning at the lowest point of the proposed survey, number the reaches sequentially upstream. Enter river mile as it corresponds to the starting and ending points of the reach. (FL:3)
10. Valley Form	Wide, glaciated U shaped Valley; Steep, narrow V shaped valley; Broad, flat plain, Alluvial outwash; etc. (See Appendix C.)(FL:2)

11. Valley Width Class

Enter the code which best describes the valley width. Valley width is the horizontal distance between the side slopes of the surrounding hills or mountains that confine the valley. 1= <30 meters (<100ft.), 2= 30m-100m (100-300ft.), 3= 100m-200m (300-600ft.), 4= >200m (>600ft.), See Appendix C for illustrations. (FL:1)

12. Flow Regime Changes

Note any large tributaries that originate in watersheds of large or similar size to the proposed surveyed watershed. Reaches can be stratified by significant changes in flow (plus or minus 30%), while other variables remain the same. Enter yes Y or no N. (FL:1)

13. Channel Entrenchment

Use the following categories: deeply entrenched, (D); moderately entrenched, (M); or shallow entrenchment, (S). See Appendix F for channel profiles that match these categories.

14. Dominant/Subdominant Channel Substrate

Enter the 2 most prevalent substrate types for the reach. See Attribute 20 on Form C for the substrate codes. (a-FL:2, b-FL:2)

15. Stream Shade

Enter the code for final percent of the stream shaded either from Form B1, Item 15 or from Form B2, Item 15 determination. Use the shade classification in the instructions for form B1. (FL:1)

16. Average Channel Gradient

Measure channel gradient as the survey crew proceeds upstream. Include several habitat types over the area that gradient is measured. Shoot gradients over a distance of no less than 50 meters. Finalize any differences with office determination, Form B1, Item 14. (FL:2)

17. Valley Length

Utilizing a map wheel and a topo map, measure the valley length from beginning and starting points of the FINAL reach length. The final reach length will be determined following the field exercise and completion of Form C. The measured distance will be the length of the straight line between these two points. (FL:3)

18. Other

Define any other criteria that you used to help make the reach stratification. This may include existing stream survey information or major disturbance areas.

19. General Comments

Write down any comments important to the aquatic/riparian resources. This is a good place to clarify some of the entries made above.

FIELD DATA ENTRY INSTRUCTIONS:
RIPARIAN IDENTIFICATION - FORM C, R6-2500/2600-30

The Riparian Identification Form - The following items should be recorded on Form C for the reaches to be surveyed. **For consistency of note taking, it is assumed that "RIGHT BANK" and "LEFT BANK" orientation refers to the direction while looking upstream.**

(NOTE INSTRUCTIONS FOR ATTRIBUTES 1 - 8 ARE LISTED IN FORM A INSTRUCTIONS):

ATTRIBUTE	MEASUREMENTS/RECORDING
9. Reach Number	Fill out while delineating on the ground, the reach number, starting from the downstream starting point, and working upstream. Utilize Form B2 to identify the reach. Reaches shall be numbered sequentially, starting with the downstream most reach (e.g., 1, 2, 3,...34). NOTE THAT THE FINAL REACH NUMBER MAY CHANGE FOLLOWING VERIFICATION DURING THE FIELD PHASE. PRIOR TO COMPUTER DATA ENTRY, SPECIFIC DELINEATION MUST OCCUR, AND THE TRUE REACH NUMBER BE ASSIGNED TO THE RESPECTIVE HABITAT UNITS.
10. Discharge	Enter the estimated/measured discharge to the nearest 20% actual flow of the stream at the time of the survey. The discharge should be the same as the previous reach and should not change unless a major tributary (contributing $\geq$25% of the flow) is encountered. At a minimum, make one measured flow at the mouth of the stream or starting point of the survey, if equipment is available. Volume of streamflow shall be measured/estimated using any of the following flowmeter/estimate methods, but preferably using a gauge or flowmeter method: 1. Price 2. Pygmy 3. Electromagnetic 4. Stream gauge 5. Velocity head rod 6. Dye 7. Other Refer to the appropriate USGS publication for the proper use and quality controls needed with the methods listed above. (FL:6)
11. Note:	Enter the frequency of sampling the Nth unit (e.g.,...if sampling habitat types at a 20% frequency, enter 5) for each habitat type. The * denotes the additional categories that require physical measurements. Do not fill in these categories in the non-measured habitat units. At a minimum, sample 10% of the habitat units. If few habitat units are anticipated because of a short stream reach, or due to a lack of encountered units, increase the measured sampling frequency.
12. Natural Sequence Number	Enter the natural sequence number (See Appendix E, Hankin-Reeves paper). Habitat units should be entered in the same order as encountered in the field survey beginning with the first habitat unit, (e.g., 1,2,3,...),

12. Natural Sequence Number (Cont.)

The numbering sequence shall remain consistent between reaches, (if Reach 1 ended at natural sequence #203, then Reach 2 shall begin at natural sequence #204). All side channels (S), parallel or adjacent units, are numbered as habitat units sequentially starting from the lowest side channel in the reach. Habitat units within the side channel **are not** stratified and measured. Treat the side channel as an independent habitat unit, and sample as such. **DO NOT** assign a natural sequence number to the side channel. When a side channel is encountered, complete the data collection the data of the habitat unit. In the comments identify the unit at which the side channel leaves the main channel and returns. (FL:4)

13. Habitat Type and Number

Enter the habitat unit type and number of that unit. In order to consider a habitat type as a unit, the habitat must be longer than the wetted width. If the unit does not meet this criteria, **DO NOT** consider it a separate unit. For extremely long habitat units (e.g., riffles 300 meters long), consider stratifying them into smaller, more manageable lengths. Assign each of the stratified segments a separate natural sequence number. In addition, consider braided channels as side channels, unless they comprise a large enough unit to be considered a separate reach. If so, identify a main channel and treat as the secondary channels as side channels. See Appendix G for a description/illustration of each habitat unit. Work with Forest personnel to develop a consistent standard for pools, glides, riffles, and side channels. This will result in lumping pool types and riffle types. More intensive surveys will generally recognize smaller units or more habitat types. Prefix the measured habitat unit with an M so these are apparent for sorting and calculating a calibration ratio later. Example: P(22), R(35), P(23), MP(23), R(36),...where the numbers in parentheses are the Habitat Unit # described below. This is more fully explained in Appendix E.
(FL:4)

P = Pool
R = Riffle
G = Glide
S = Side Channel (DO NOT ASSIGN A NATURAL SEQUENCE NUMBER TO THIS HABITAT TYPE)
F = Special Cases (culverts, falls, etc.)
D = Dry channel (note only length)

14. Length

Enter the ocularly estimated thalweg length for each habitat unit. The length will be ocularly estimated at each unit and measured at each Nth unit. Estimated and measured (E&M) values shall be reported to the nearest 1/3m or foot. Subsequent fish sampling will be accomplished in some of these habitat units. (FL:5)

15. Width

Enter the ocularly estimated mean width for each habitat unit. The width will be ocularly estimated at each unit and measured at each Nth unit. (E&M:1/3m, ft; FL:4)

16. Max Depth

Enter the ocularly estimated maximum depth for each unit. The maximum depth will be ocularly estimated at each unit and measured at each Nth unit. Maximum depth can be easily measured at each habitat unit with a scale stick if the depths are typically less than 4 feet (1.2 meters) (E&M:0.05m, 0.2ft; FL:4)

17. Depth at Pool Tail Crest

Enter the estimated/measured depth at pool tail crest (riffle crest) for every pool habitat unit. This location is upstream of the point where the water surface slope breaks into the downstream riffle. Measure the maximum depth at this point along the width of the hydraulic control feature that forms the pool. This measurement is for calculating residual pool volume (e.g., maximum depth minus pool tail crest depth = maximum residual pool depth). The depth will be ocularly estimated at each pool unit and measured at each Nth pool unit. Depth at pool tail crest can be easily measured at each pool tail with a scale stick. See Lisle's paper (1987) for additional information regarding residual pool volume. (E&M:0.05m, 0.2ft; FL:6)

18. Bankfull Width

Enter the measured bankfull width (BFW) at each Nth pool tail crest. Bankfull is defined as the point where the streamflow would leave the channel under a high flow condition. On totally constrained channels, bankfull width will be the same as width. (M:1/3m, 1ft; FL:4)

19. Bankfull Depth

Enter the measured bankfull depth at each Nth pool tail crest. The measurement will be made at the same location as the pool tail crest. (M:1/3m, 1ft; FL:4)

20. Stream Bed Substrate

Enter the ocularly measured dominate and subdominate substrates occupying each unit by area. Use the following size classes and qualifiers:

S =Sand, Silt, and Clay	(<0.2cm, 0.08in)
G =Gravel (pea to hardball size)	(>0.2cm-6.4cm, 0.08-2.5in)
C =Cobble (hardball size to basketball size)	(>6.4cm-25.6m, 2.5-10in)
SB =Small Boulder	(>25.6cm-102.4cm, >10-40in)
LB =Large Boulder	(>102.4cm, >40in)
R =Bedrock	

(FL:2)

21. Woody Material (WM)

Enter the ocularly estimated woody material within the bankfull channel for each unit. This includes live, leaning material that has the potential to fall into the stream. The leaning material must lean over the area defined by the bankfull width; if it leans, but is not within this area, do not include it as woody material. Enter the number of pieces by size category, if $\geq$ 99 than enter 99. If the WM does not meet the size criteria, but is 2 times longer than the bankfull channel width, then record the piece as small.

21. Woody Material (WM) Cont.

Make note of rootwads and other woody material in the comments section of the form. Note that the diameters listed are minimum diameters. Use the following classes (brush, small and large) and qualifiers:

East Side Forests:

B = Diameter > 15 cm (6in), length > 6.5 m (20ft)
S = Diameter > 30 cm (12in), length > 10 m (35ft)
L = Diameter > 50 cm (20in), length > 10 m (35ft)

West Side Forests

B = Diameter > 30 cm (12in), length > 8 m (25ft)
S = Diameter > 60 cm (24in), length > 16 m (50ft)
L = Diameter > 90 cm (36in), length > 16 m (50ft)

22. Total Effective Cover

a: Percent - Enter the code for the cover category that is ocularly estimated for each unit for the desired species and size class(es) of fish. What is cover for young of the year salmonids will not suffice for age 1 + fish. Visualize the wetted surface area of the unit from overhead and record the percentage class of this area that is occupied by cover:

1 = 0 to 5% total cover
2 = 6 to 20% total cover
3 = 21 to 40% total cover
4 = > 40% total cover

b&c: Cover Type - Enter the dominate and subdominate cover types for each unit. Use the following cover codes:

U = Undercut banks
S = Substrate
D = Depth > 1 meter
W = Wood Material
T = Turbulence
A = Aquatic/Emergent Veg
H = Overhanging vegetation (<10" (0.3m) above the water surface) (FL:a=1, b&c=1)

23. Temperature

a. Take stream temperatures 3 times a day (morning, noon, late afternoon) and enter to the nearest degree.
b. Enter the military time at the time temperatures are taken (to the nearest hour, 1-24). (FL:a=2,b=4)

24. Embeddedness

Enter Y for Yes, N for No for each Nth habitat unit. This includes pools, riffles and glides. If the ocularly estimated cobble embeddedness in the unit is >35% by volume, enter Y. If there is no cobble, use gravel embeddedness. If substrates for the habitat unit DO NOT contain either gravel or cobble, insert the letter A. See Appendix H for illustration of embeddedness. (FL:1)

25. Streambank Substrate

a&b: Enter the dominate and subdominate substrates of the upper 1/3 of the bankfull channel streambanks for each Nth habitat unit. Use the codes for substrate as shown in #20 (substrate) above. See Appendix I for illustrations of streambank. (FL:a=1,b=1)

26. Streambank Ground Cover

Enter the percentage of ground cover for the upper 1/3 of the streambank for each Nth habitat unit either vegetatively or physically armored against scour from bankfull flow. Take an average of both banks and combine for a total percentage figure. Use the following percentage classes:

1 = 0-25%
2 = 26-50%
3 = 51-75%
4 = 76-100%

Armoring can be provided by bedrock, substrate materials, vegetation and their roots, woody material, mosses, etc. (FL:1)

27. Floodplain Vegetation

a: Enter the existing floodplain vegetation successional class for each Nth unit by the following codes (see Appendix J for illustration and definitions of successional stages).

	DIAMETER CLASS
GF = Grassland/Forb Condition	
SS = Shrub/Seedling Condition	
SP = Sapling/Pole Condition	(< 8.0" dbh)
ST = Small Trees Condition	(8.0"- 20.9" dbh)
LT = Large Tress Condition	(21" - 32.0" dbh)
MT = Mature Trees Condition	(> 32" dbh)

b&c: Enter the dominant and subdominant species of vegetation growing on the streambank for each Nth unit utilizing the species categories listed in Appendix J. If species are in seral class GF, enter GF; if species are in seral class SS, enter SS with the correspending height class code (e.g. SS3, if shrubs are between 5 and 10 feet tall), in addition, use the conifer or hardwood species list to identify dominant or subdominant species; if seral class SP, ST, LT, or MT, utilize the following species descriptors (also found in Appendix J):

Hardwood:
HA = Alder
HB = Bigleaf maple
HC = Cottonwood, ash, poplar
HD = Dogwood
HE = Elderberry
HL = Liveoak, canyon
HM = Madrone
HO = Oak, Oregon white, California black
HQ = Quaking aspen
HT = Tanoak
HV = Vine Maple
HW = Willow
HX = Other

27. Floodplain Vegetation (Cont.)

Conifer:

CA = Subalpine fir, mountain hemlock, whitebark pine
CC = Cedar, western red
CD = Douglas fir
CE = Subalpine fir - engelmann spruce
CF = Fir, silver and noble
CH = Hemlock, western
CJ = Juniper
CL = Lodgepole pine, shore pine
CM = Mountain Hemlock
CP = Ponderosa pine, Jeffrey Pine
CQ = Western white pine
CR = Red fir
CS = Spruce, sitka
CT = Port Orford cedar
CW = White fir, grand fir
CY = Yew
CX = Other

Shrubland height classes:
1 = 0'-2'; 2 = 2'-5'; 3 = 5'-10'; 4 = > 10'

Example: Eastside - Seral stage is Grassland, with grasses dominant and shrubs 3 feet tall subdominant: a: GF, b: GF, c: SS2. Or if seral stage is shrub/sapling dominant, with alder subdominant: a: SS3, b: SS, c: HA.

Westside - seral stage is large trees with Douglas fir dominant and alder subdominant:
a: LT, b: CD, c: HA.
(FL:a=3,b&c=2 each)

28. Comments

Enter comments regarding any of the above evaluations and photos; or geomorphological, hydrologic, or biological observations. For culverts, falls, chutes, and dams, use the SPECIAL CASE FORM (Form C1) to document specific information regarding these features. Stream gradient measurements should be made on a frequent basis and documented here. Shoot the gradients over an area that contains several habitat units (no less than 40 meters). Other suggested notable features to note are:

Fish passage: jams, barriers, fish habitat improvement opportunities, etc.

Watershed concerns: slides, erosion areas, streambank damage, watershed rehabilitation potential, etc.

Riparian ecosystem classification: potential riparian ecoclass. Some Forests have more fully developed eco-class types. Update with the appropriate ecosystem classification for the reach or unit.

Other: diversions, mining, dredging, filling, riprap, etc. Also include reaches that are within Wild and Scenic rivers and wilderness areas.

28. Comments (Cont.)

Tributaries: If the tributary is perennial, fill in paramenters 13-17 and 20-23 on Form C. Note the habitat unit at the confluence, estimated discharge, gradient immediately upstream of mouth (30m), % contribution to the flow of the main stem, and temperature of mainstem (above trib) and tributary. **DO NOT GIVE THE TRIBUTARY UNIT A NATURAL SEQUENCE NUMBER.**

End of Survey: Note the reasons for ending the survey at a given point.

This information will give the reviewer insight as to the reasoning for ending the survey, and will minimize the need to re-examine that point in the watershed.

NOTE: Description of underlined features should include the location and an objective description of situation. Photographs are helpful in recording notable features. General characteristics should be noted in comments section for other features noted.

FIELD DATA ENTRY INSTRUCTIONS:
SPECIAL CASES FORMS C1 AND C2, R6-2500/2600-31 AND 32

These forms are to supplement information collected on culverts, falls, chutes and dams that have been noted in the Comments section on FORM C. The forms are self explanatory. If photos are taken of the feature, note the photo # and film roll # in the comments section of Form C, as well as in Attributes 21 and 18 of Forms C1 and C2.

FIELD DATA ENTRY INSTRUCTIONS:
FISH USE AND RELATIVE ABUNDANCE FORM D, R6-2500/2600-40

Form D is to be used to record fish information. The survey intensity may vary between Forests/Districts. Fish information should, at a minimum, be recorded at each 10th pool, 15th riffle and 20th glide entered on Form C. Snorkling, electrofishing, or seine methods may be used to gather this information.

(NOTE INSTRUCTIONS FOR ATTRIBUTES, 1 - 8 ARE LISTED IN FORM A INSTRUCTIONS):

ATTRIBUTE	MEASUREMENTS/RECORDING
9. Reach Number	Fill out only after the field survey has been completed, identifying the range of reaches (e.g., 1-11, if 11 reaches had been identified on the ground).
10. Discharge	Enter the estimated/measured discharge to the nearest 20% actual flow of the stream at the time of the survey. The discharge should be the same as the previous reach and should not change unless a major tributary (contributing $\geq$25% of the flow) is encountered. At a minimum, make one measured flow at the mouth of the stream, if equipment is available. Volume of streamflow shall be measured/estimated using any of the following flowmeter/estimate methods, but a gauge or flowmeter method is preferred:

10. Discharge (Cont.)	1. Price 2. Pygmy 3. Electromagnetic 4. Stream gauge	5. Velocity head rod 6. Dye 7. Other

Refer to the appropriate USGS publication for the proper use and quality controls needed with the methods listed above. (FL:6)

11. Natural Sequence Number — Enter the natural sequence number as listed in Attribute 12, Form C. (FL:5)

12. Habitat Type and Number — Enter the habitat type as listed in Attribute 13, Form C.

13. Method — Enter the abreviation for method: Seine (S), Snorkel (SN), Electroshock (E).

14. Species — Enter the species, and relative abundance of the fishes observed at each sampled habitat unit. Use the following codes for recording fish information:

ADULT	JUVENILE
1 = 1-5 fish	1 = 1-25 fish
2 = 6-10 fish	2 = 26-75 fish
3 = >10 fish	3 = > 75 fish

If the fish numbers in these categories are too low, the Forest and District fish biologists will need to develop a range of fish numbers appropriate for the stream basin and reach being surveyed. In larger stream systems or streams with anadromous fish the above numbers may be too low. State the range of fish numbers to clarify data analysis. For age classes of fishes, distinguish between sub-legal and legal size fish or juvenilles and adults. See Appendix B for species abbreviations.

15. Comments — Enter comments regarding any of the above evaluations and document photos; or geomorphological, hydrologic or biological observations.

220.8 Outputs. The Habitat Inventory/Field Phase generates information for Forms C and D. Development of summary tables and graphs aggregates data and provides for comparison/analysis. Use the query functions of your computer software to sum and average physical parameters and attributes. At a minimum tables 2-? will be developed to display data describing the aquatic/riparian characteristics.

230 - LEVEL III - IMPLEMENTATION/MONITORING/EVALUATION

230.1 - Requirement. The Level III surveys provide more detailed data for project work and monitoring of resource activities (i.e. timber sales, restoration/enhancement projects, grazing impacts, or range allotment planning). Often these surveys focus on specific reaches or stream sections. The information is later used for specific prescriptions or to monitor changes in habitat parameters due to project implementation with a moderate degree of precision. Utilizing this level of survey intensity gives a somewhat accurate inventory of fish populations and habitat preferences.

230.2 - 230.5 - Future.

240 - LEVEL IV - RESEARCH

240.1 - Requirement. The Level IV surveys are usually conducted by groups or teams to provide high-quality data on aquatic/riparian habitat or fish populations. The information recorded under this intensity would be statistically-sound and provide detailed evaluation and monitoring of restoration projects, timber sales, grazing impacts, etc. Cause and effect relationships could be accurately documented (i.e., fish-sediment, water temperature-shade or correlating predictor models).

240.2 - 240.5 - Future.

STREAM IDENTIFICATION FORM A

Page: __of__

Date:___/___/___

1. State ___ 2. County ___ 3. Forest ___ 4. District ___ YY/MM/DD

5. Stream Name: ____________________

6. Watershed Code ___, ___, ___, ___, ___, _.

7. Forest: ____________________

8. Team: ____________________

---

9. USGS Quad ____________________

10. Stream Order _ _

11. Watershed Area _ _ _ _ _ _ Hectares (Acres)

12. Stream Class _ _

13. Fishery _ _,_ _,_ _,_ _. Source ____________________

14. Flow Data _. Source ____________________

15. Water Quality Data _. Source ____________________

16. Macroinvertebrate Data _. Source ____________________

17. Previous Surveys _. Source ____________________

18. Historical Land Use Data: ____________________

19. Comments: ____________________

PRELIMINARY REACH IDENTIFICATION FORM B1 (OFFICE) Page: __of__
Date:___/___/___
YY/MM/DD

1. State ___ 2. County ___ 3. Forest ___ 4. District ___
5. Stream Name: ______________________________
6. Watershed Code ___, ___, ___, ___, ___, _.
7. Forest: ______________________________
8. Team: ______________________________

---

9. Reach # ___ RM ___ to ___

10. Valley Form ____________
11. Valley Width Class _1___2___3___4
12. Flow Regime Change ____________
13. Sinuosity _H___M___L___S___
14. Average Reach Gradient ____________
15. Stream Shade __1____2____3____4__
16. Other ____________

17. General Comments: ____________

Reach # ___ RM ___ to ___

Valley Form ____________
Valley Width Class _1___2___3___4__
Flow Regime Change ____________
Sinuosity _H___M___L___S___
Average Reach Gradient ____________
Stream Shade __1____2____3____4__
Other ____________

General Comments: ____________

---

9. Reach # ___ RM ___ to ___

10. Valley Form ____________
11. Valley Width Class _1___2___3___4
12. Flow Regime Change ____________
13. Sinuosity _H___M___L___S___
14. Average Reach Gradient ____________
15. Stream Shade __1____2____3____4__
16. Other ____________

17. General Comments: ____________

Reach # ___ RM ___ to ___

Valley Form ____________
Valley Width Class _1___2___3___4__
Flow Regime Change ____________
Sinuosity _H___M___L___S___
Average Reach Gradient ____________
Stream Shade __1____2____3____4__
Other ____________

General Comments: ____________

---

9. Reach # ___ RM ___ to ___

10. Valley Form ____________
11. Valley Width Class _1___2___3___4
12. Flow Regime Change ____________
13. Sinuosity _H___M___L___S___
14. Average Reach Gradient ____________
15. Stream Shade __1____2____3____4__
16. Other ____________

17. General Comments: ____________

Reach # ___ RM ___ to ___

Valley Form ____________
Valley Width Class _1___2___3___4__
Flow Regime Change ____________
Sinuosity _H___M___L___S___
Average Reach Gradient ____________
Stream Shade __1____2____3____4__
Other ____________

General Comments: ____________

FINAL REACH IDENTIFICATION FORM B2 (FIELD)

Page ___ of ___
Date:___/___/___
YY/MM/DD

1. State ___ 2. County ___ 3. Forest ___ 4. District ___
5. Stream Name: ______________________________
6. Watershed Code ___, ___, ___, ___, ___, _.
7. Forest: ______________________________
8. Team: ______________________________

---

9. Reach # ___ RM ___ to ___
10. Valley Form ____________
11. Valley Width Class _1___2___3___4
12. Flow Regime Change ____________
13. Channel Entrenchment __D__M__L__
14. Dominant/Subdominant a.)____b.)___ Substrate
15. Stream Shade __1____2____3____4___
16. Average Channel Gradient__________
17. Valley Length ____________
18. Other ____________
19. General Comments: ____________

Reach # ___ RM ___ to ___
Valley Form ____________
Valley Wid Class _1___2___3___4___
Flow Regime Change ____________
Channel Entrenchment __D__M__L__
Dominant/Subdominant a.)____b.)____ Substrate
Stream Shade __1____2____3____4____
Average Channel Gradient __________
Valley Length ____________
Other ____________
General Comments: ____________

---

9. Reach # ___ RM ___ to ___
10. Valley Form ____________
11. Valley Width Class _1___2___3___4
12. Flow Regime Change ____________
13. Channel Entrenchment__D__M__L___
14. Dominant/Subdominant a.)____b.)___ Substrate
15. Stream Shade __1____2____3____4___
16. Average Channel Gradient__________
17. Valley Length ____________
18. Other ____________
19. General Comments: ____________

Reach # ___ RM ___ to ___
Valley Form ____________
Valley Wid Class _1___2___3___4___
Flow Regime Change ____________
Channel Entrenchment__D__M__L__
Dominant/Subdominant a.)____b.)____ Substrate
Stream Shade __1____2____3____4____
Average Channel Gradient __________
Valley Length ____________
Other ____________
General Comments: ____________

---

9. Reach # ___ RM ___ to ___
10. Valley Form ____________
11. Valley Width Class _1___2___3___4
12. Flow Regime Change ____________
13. Channel Entrenchment__D__M__L___
14. Dominant/Subdominant a.)____b.)___ Substrate
15. Stream Shade __1____2____3____4___
16. Average Channel Gradient__________
17. Valley Length ____________
18. Other ____________
19. General Comments: ____________

Reach # ___ RM ___ to ___
Valley Form ____________
Valley Wid Class _1___2___3___4___
Flow Regime Change ____________
Channel Entrenchment__D__M__L__
Dominant/Subdominant a.)____b.)____ Substrate
Stream Shade __1____2____3____4____
Average Channel Gradient __________
Valley Length ____________
Other ____________
General Comments: ____________

SPECIAL CASES FORM C1 (FIELD)

Page: __of__
Date:___/___/___
YY/MM/DD

1. State ___ 2. County ___ 3. Forest ___ 4. District ___
5. Stream Name: ______________________________
6. Watershed Code ___, ___, ___, ___, ___, _.
7. Forest: ______________________________
8. Team: ______________________________
(circle observer)

---

9. Reach # _____ 10. Natural Sequence # _____ 11. Culvert # _____

12. Type of structure (check)
Round Pipe Box Arch Open Arch Open Box Eliptical

13. Length of Structure ________(ft) 14. Diameter or width ________ (ft)
15. Gradient of Structure ____________% 16. Are Baffles Present? __________
17. Pool present below structure (circle) Yes No
18. Pool Length ______, Width ______, Depth ______
19. Jumping distance into culvert from pool: Height ______
20. Stream above culvert: Width ______, Gradient ________
21. Other Comments: ______________________________

---

9. Reach # _____ 10. Natural Sequence # _____ 11. Culvert # _____

12. Type of structure (check)
Round Pipe Box Arch Open Arch Open Box Eliptical

13. Length of Structure ________(ft) 14. Diameter or width ________ (ft)
15. Gradient of Structure ____________% 16. Are Baffles Present? __________
17. Pool present below structure (circle) Yes No
18. Pool Length ______, Width ______, Depth ______
19. Jumping distance into culvert from pool: Height ______
20. Stream above culvert: Width ______, Gradient ________
21. Other Comments: ______________________________

---

9. Reach # _____ 10. Natural Sequence # _____ 11. Culvert # _____

12. Type of structure (check)
Round Pipe Box Arch Open Arch Open Box Eliptical

13. Length of Structure ________(ft) 14. Diameter or width ________ (ft)
15. Gradient of Structure ____________% 16. Are Baffles Present? __________
17. Pool present below structure (circle) Yes No
18. Pool Length ______, Width ______, Depth ______
19. Jumping distance into culvert from pool: Height ______
20. Stream above culvert: Width ______, Gradient ________
21. Other Comments: ______________________________

SPECIAL CASES FORM C2 (FIELD)

Page: __of__
Date:___/___/___
YY/MM/DD

1. State ___ 2. County ___ 3. Forest ___ 4. District ___
5. Stream Name: ____________________
6. Watershed Code ___, ___, ___, ___, ___, _.
7. Forest: ____________________
8. Team: ____________________
(circle observer)

---

9. Reach # _____ 10. Natural Sequence # _____
11. Falls/ Chute/ Dam (circle one) # ________
12. Stream Survey Mile: ________ 13. Topo map elevation: ___________
14. Size: Length _______ Width ______ Height ______
15 Gradient: _______%
16. Is pool present below structure (circle one) Yes No
17. Pool Length ______ Width ______ Depth _______
18. Other Comments: ____________________

---

9. Reach # _____ 10. Natural Sequence # _____
11. Falls/ Chute/ Dam (circle one) # ________
12. Stream Survey Mile: ________ 13. Topo map elevation: ___________
14. Size: Length _______ Width ______ Height ______
15 Gradient: _______%
16. Is pool present below structure (circle one) Yes No
17. Pool Length ______ Width ______ Depth _______
18. Other Comments: ____________________

---

9. Reach # _____ 10. Natural Sequence # _____
11. Falls/ Chute/ Dam (circle one) # ________
12. Stream Survey Mile: ________ 13. Topo map elevation: ___________
14. Size: Length _______ Width ______ Height ______
15 Gradient: _______%
16. Is pool present below structure (circle one) Yes No
17. Pool Length ______ Width ______ Depth _______
18. Other Comments: ____________________

---

9. Reach # _____ 10. Natural Sequence # _____
11. Falls/ Chute/ Dam (circle one) # ________
12. Stream Survey Mile: ________ 13. Topo map elevation: ___________
14. Size: Length _______ Width ______ Height ______
15 Gradient: _______%
16. Is pool present below structure (circle one) Yes No
17. Pool Length ______ Width ______ Depth _______
18. Other Comments: ____________________

RIPARIAN IDENTIFICATION FORM C

Page: __of__
Date:___/___/___
YY/MM/DD

1. State ___ 2. County ___ 3. Forest ___ 4. District ___
5. Stream Name: ______________________________
6. Watershed Code ___, ___, ___, ___, ___, _.
7. Forest: ______________________________
8. Team: ______________________________
(circle the observer)
9. Reach Number _____

---

10. Discharge _ _ _ cfs (circle one: MEASURED or ESTIMATED)

11. NOTE: * Indicates information to be gathered at the Nth unit only.
Enter the Sampling frequency: Pool ___ Riffle ___ Glide ___

Measurement in METRIC or ENGLISH units: M E

12. NATURAL SEQUENCE NUMBER										
13. HABITAT TYPE AND NUMBER										
14. LENGTH										
15. WIDTH										
16. MAX DEPTH										
17. DEPTH @ POOL TAIL CREST										
18. BANKFULL WIDTH *										
19. BANKFULL DEPTH *										
20. STREAM BED SUBSTRATE	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX									
a. Dominate										
b. Subdominate										
21. WOODY MATERIAL (#pieces)	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX									
a. B (d=>15cm or 30cm										
b. S (d=>30cm or 60cm										
c. L (d=>50cm or 90cm										
22. TOTAL EFFECTIVE COVER	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX									
a. %										
b. Dominate										
c. Subdominate										
23. TEMPERATURE	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX									
a. Water (C F)										
b. Time (1-24)										
24. EMBEDDEDNESS (>35%) *										
25. STREAMBANK SUBSTRATE *	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX									
a. Dominate										
b. Subdominate										
26. STREAMBANK GROUND COVER*										
27. FLOODPLAIN VEGETATION *	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX									
a. Successional class										
b. Dominant species										
c. Subdominant species										
28. COMMENTS										

FISH USE AND RELATIVE NUMBERS FORM D

Page: __of__
Date:___/___/___
YY/MM/DD

1. State ___ 2. County ___ 3. Forest ___ 4. District ___
5. Stream Name: ______________________________
6. Watershed Code ___, ___, ___, ___, ___, _.
7. Forest: ______________________________
8. Team: ______________________________
(circle the observer)
9. Reach Number _____

---

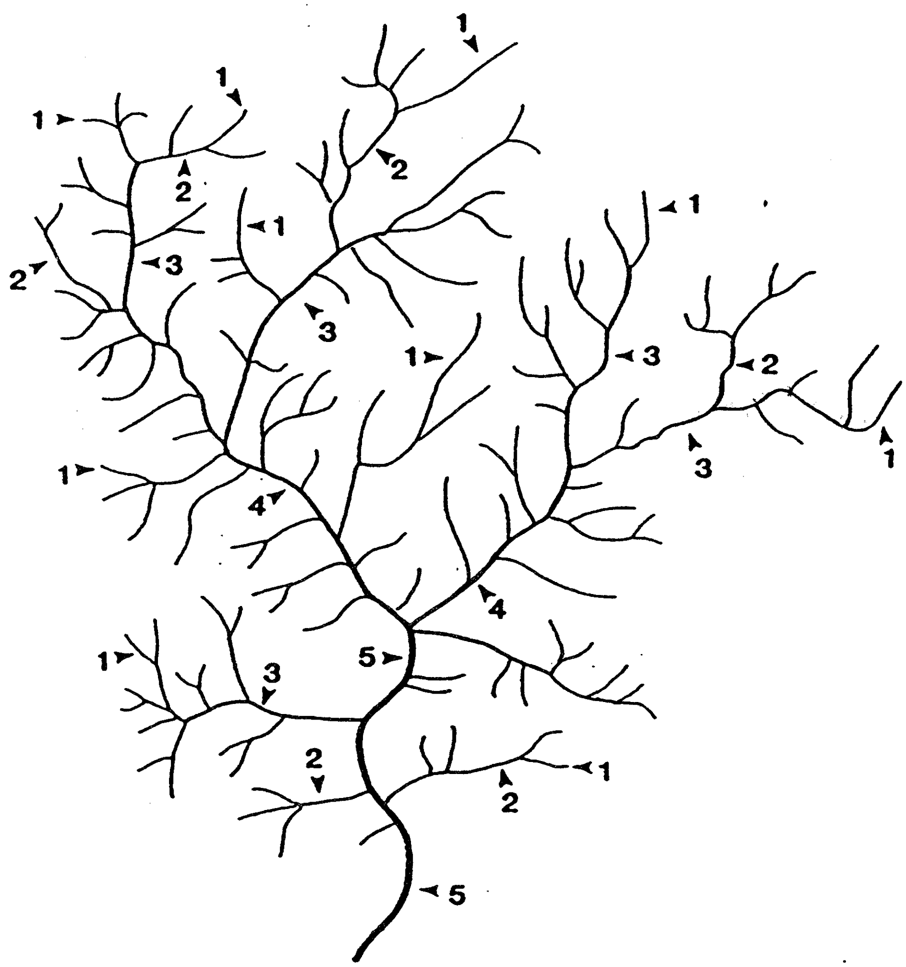
10. Discharge ____ cfs (Estimated/Measured -- circle one)

METHOD: Seine (S) Snorkel (SN) Electroshock (E)

NOTE: * ADULT: 1 = 1-5 fish, 2 = 5-10 fish, 3 = > 10 fish
NOTE: * JUVEN: 1 = 1-25 fish, 2 = 25-75 fish, 3 = > 75 fish

11. NAT SEQUENCE NUMBER								
12. HABITAT TYPE & #								
13. METHOD								
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX							
14. SPECIES								
* JUVENILE (Sub-legal)								
* Adult (legal)								
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX							
SPECIES								
* JUVENILE (Sub-legal)								
* Adult (legal)								
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX							
SPECIES								
* JUVENILE (Sub-legal)								
* Adult (legal)								
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX							
SPECIES								
* JUVENILE (Sub-legal)								
* Adult (legal)								
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX							
SPECIES								
* JUVENILE (Sub-legal)								
* Adult (legal)								
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX							
SPECIES								
* JUVENILE (Sub-legal)								
* Adult (legal)								
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX							
SPECIES								
* JUVENILE (Sub-legal)								
* Adult (legal)								
	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX							
SPECIES								
* JUVENILE (Sub-legal)								
* Adult (legal)								
15. COMMENTS								

APPENDIX A



STREAM ORDERS

Stream order: The designations (1, 2, 3, etc) of the relative position of stream segments in a drainage basin network: the smallest, unbranched, perennial tributaries, terminating at an outer point, are designated order 1; the junction of two first-order streams produces a stream segment of order 2; the junction of two second-order streams produces a stream segment of order 3, etc. Use of small-scale maps (<2"/mile) may cause smaller streams to be overlooked, leading to gross errors in designation. Ideally designation should be determined on the ground or from large-scale air photos.

APPENDIX B

ABBREVIATIONS FOR FISHES

Use the following two digit codes for describing fishes in survey forms:

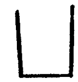
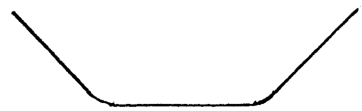
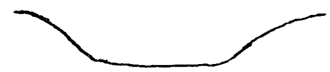
Bk - Eastern Brook Trout	Pk - Pink Salmon
Ch - Chinook Salmon	Sh - Steelhead Trout
Ct - Cutthroat Trout	Bt - Bull Trout
So - Sockeye Salmon	Co - Coho Salmon
Bn - Brown Trout	Rb - Rainbow Trout
Cm - Chum Salmon	Wf - Whitefish
Rd - Redband Trout	NG - Non-game species
Uk - Unknown	

APPENDIX C

VALLEY CHARACTER

VALLEY FORM

(Enter Code Only!)

Code	Type	Side Slope	ILLUSTRATION
1 =	Box-like canyon	Steep: > 60%	
2 =	Narrow V-shaped floor width < 100 ft.	Steep: > 60%	
3 =	Moderate V-shaped floor width < 100 ft.	Moderate: 30-60%	
4 =	Low V-shaped floor width < 100 ft.	Low: < 30%	
5 =	U-shaped floor width > 100 ft.	Moderate to steep: > 30%	
6 =	Through-like open short slope lengths	> 30%, mostly 30-60%	
7 =	Broad, trough-like	Low: < 30%	
8 =	Narrow flat-floored floor width 100-300 ft.	Moderate to steep: >30%	
9 =	Moderate flat-floored floor width 300-600 ft.	Moderate to steep: >30%	
10=	Wide flat-floored floor width > 600 ft.	Moderate to steep: >30%	

VALLEY WIDTH CLASS

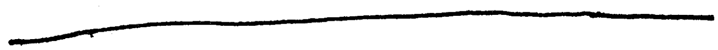
(Enter Code Only!)

Code	Width
1 =	< 30 meters wide (100 feet)
2 =	30-100 meters wide (100-300 feet)
3 =	100-300 Meters (300-600 feet)
4 =	> 300 Meters (> 600 feet)

APPENDIX D

STREAM SINUOSITY CLASSES

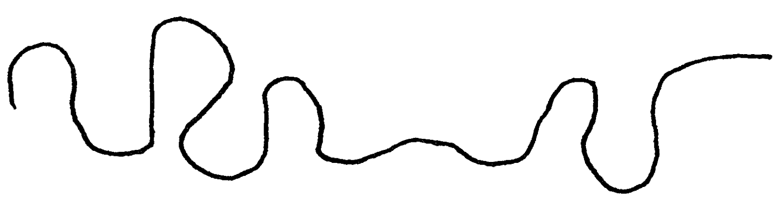
S =



L =

M =

H =



S = Straight

L = Low

M = Moderate

H = High

APPENDIX E

Use of Visual Methods for Estimating Fish Abundance and Habitat Areas in Small Streams[1]

David G. Hankin
Dept. of Fisheries
Humboldt State University
Arcata, CA 95521

Gordon H. Reeves
USDA Forest Service
Pacific Northwest Experiment Station
Corvallis, OR 97331

[1] Based on: Hankin, D.G., and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Can. J. Fish. Aquat. Sci. 45: in press.

I. Introduction

There is an increasing awareness among fishery biologists of the need to approach the planning and implementation of resource management programs and habitat enhancement projects from a basin-wide persepective. Biologists have generally employed one of two methods to generate a basin-wide perspective of fish production and habitat quantity: (a) extrapolation from "representative" reaches or "index" areas, or (b) systematic selection of equal length sections of stream. It has been generally assumed that either of these methods can provide accurate estimates of basin features such as total habitat areas and fish numbers.

Recent evidence has shown that use of "representative" reaches can result in generation of inaccurate and misleading notions of basin-wide conditions, however. For example, Everest et al. (1986) attempted to estimate the total amount of habitat and total fish numbers in Fish Creek, Oregon, by extrapolation from five "representative" reaches. A survey based on a statistically valid sampling design that ensures that all habitat types are sampled was carried out concurrently. Extrapolation from the "representative" reaches resulted in an apparent serious over-estimation of total habitat area when compared to the statistically valid survey. Overestimation of total habitat area in turn led to overestimation of fish abundance. In another instance, Bisson (1988) estimated the number of fish in a small basin in Washington using different sets of "representative" reaches drawn from different portions of the stream. He found that estimated numbers of fish varied by several orders of magnitude depending on choice of "representative" reaches.

In this paper we present cost-effective sampling designs for estimating total habitat areas and total fish numbers in small streams based on visual estimation (Hankin and Reeves 1988). We consider practical application of these sampling designs in the field, and we also discuss procedures for construction of confidence intervals around calculated estimates. In addition to providing estimates of total habitat areas and fish abundance, use of these sampling designs can produce detailed maps showing the size, sequence of occurrence, and location of all stream habitat units. Data generated using these procedures may be used for identification of limiting factors and for inventory and monitoring purposes.

II. Estimating Total Habitat Areas

A. Classification of habitat units

This sampling design places substantial reliance on visual estimation of the areas of indentifiable habitat units. The first step in implementation of this design is therefore determination of what habitat unit types area of interest. We suggest use of definitions from Bisson et al. (1981) or those in the "Glossary of Stream Habitat Terms" (Habitat Inventory Committee, Western

APPENDIX E

Division of the American Fisheries Society 1985). Consistent definitions and criteria for classification of habitat unit types are vital to the success of a stream survey. Without such consistency, for example, it would be impossible to compare data collected by different observers in the same stream. Standardized definitions also allow comparison of habitat characteristics between streams.

Determination of the particular types of habitat units that are to be identified will depend on the purpose of a survey. Montioring efforts usually require a more detailed classification of habitat unit types than general inventories. For basic inventory purposes it may be adequate to classify habitat types into very general categories such as pools and riffles. For detailed monitoring purposes, however, it may be necessary to define additional categories such as glides, side channels, and special types of pool units (e.g. break, lateral scour and plunge pools). Monitoring of enhancement efforts may be directed at a specific habitat type that is to be created. Regardless of the purpose of a survey, the types of habitat types that are of interest must be identified <u>before</u> the survey is initiated.

Prior to field work, all habitat characteristics that are to be measured should be identified. As for selection of habitat unit types, additional habitat characteristics to be measured will depend on survey purpose. The sampling design we describe below allows collection of a large amount of data at individual habitat units. Data generally collected included unit length, mean unit width, maximum unit depth, number of pieces of wood in given size categories, and dominant substrate.

B. <u>Measurements at each unit</u>

Two people are required for data collection for this method. One person (the "observer") is responsible for actual data collection whereas the other is responsible for data recording (the "recorder"). All visual or "eye" estimates described below should be made <u>only</u> by the observer.

The observer begins at the first habitat unit in a stream, identifies its habitat unit type, and then <u>visually</u> estimates its length, mean width, and area (length x mean width). Other habitat characteristics may also be measured or estimated. Points of reference, such as tributary junctions, road crossings, etc., should be noted by the recorder so that location in the basin can be better identified when the survey is completed.

As for definition of habitat units types, it is imperative that standardized criteria are followed for all measurements, visual or other. For example, it is often difficult to judge an appropriate length measurement for a pool that is irregularly shaped at one end. We have adopted the rule that the "end" of the pool is the midpoint between the point at which the pool becomes irregular in shape and the irregular endpoint of the pool.

In a systematic sample of units within a given habitat type, accurate measurements of unit characteristics are made in addition to visual estimates. For example, suppose one wanted to obtain accurate measurements of area in 10% of all pools in some reach of a stream (i.e. a sampling fraction of 10% is desired). The first unit to be measured should be determined by drawing a random number between 1 and 10 and making an accurate measurement of pool area in the pool that is selected. Then, accurate measurements of pool area should be made in every tenth pool thereafter. The initial "random start" might be 7, for example, in which case accurate measurements of pool area would be made in pool units 7, 17, 27, etc..

Selection of valid systematic samples for accurate measurements of habitat unit characteristics requires attention to two details. First, independent random starts should be drawn for each different classified habitat unit type. Second, once the initial random start has been selected for a given habitat unit type, then all subsequent accurate measurements must be made at exactly the same (systematic) interval between units. For example, suppose that the initial random start were 7 and that every tenth pool unit thereafter was to be accurately measured, as above. If field work on day "one" ended at pool unit 44, then the first pool unit for accurate measurements on day "two" should be pool unit 47, and subsequent units would be 57, 67, etc..

Accurate measurements of habitat unit areas should be made according to the following procedure: (a) measure unit widths at fixed 1-2 m intervals along the length of the unit and calculate the mean of these width measurements; (b) multiply mean width by total unit length to determine habitat unit area. Note that choice of interval between width measurements should depend on the complexity of a given habitat unit. A 2 m fixed interval may provide an accurate measurement of mean width in a broad, flat, straight riffle unit, whereas a 1 m interval may be required for accurate measurement of mean width in a complex, irregularly shaped pool unit.

If subsequent estimation of fish abundance is also to be carried out in the survey, the individuals responsible for collecting physical data should also mark and identify those units that will later be sampled for fish. The procedure for selection of units for fish sampling is described in part III of this paper. Both the lower and upper boundaries of these units should be marked with highly visible plastic flagging that has the unit type and unit number marked on it.

C. Data entry and storage

Use of this samping design generally results in generation of large amounts of survey data. It is simplest to enter, store, and manipulate data in a computer spreadsheet such as LOTUS. [A spreadsheet will soon be available on the DG (Data General) system for U.S. Forest Service biologists.] Data for individual

APPENDIX E

habitat units should be entered on the computer in the same order in which units were encountered in the field survey (e.g. pool 1, glide 1, riffle 1, pool 2, glide 2, etc.). This procedure will retain the natural habitat unit location sequence for later mapping purposes, and the spreadsheet will allow easy sorting by habitat unit type regardless of order of data input. Most data manipulations and calculculations associated with use of this sampling design can generally be carried out within the spread-sheet format.

D. Calculations and formulas

The basic premise of this method is that if visual estimates of habitat unit areas are highly correlated with accurate estimates of habitat unit areas, then one can "correct" for the possible bias of visual estimates through calculation of a "calibration ratio". The calibration ratio represents an estimate of the true ratio of true habitat unit area as compared to visually estimated area. This calibration ratio is calculated based on n paired visual and accurate estimates made in selected habitat units using

(1) Calibration ratio $= \hat{Q} = \sum^{n} m_i / \sum^{n} x_i$

where m_i = true (accurately measured) area of unit i;

x_i = visual estimate of area of unit i; i = 1,2,..,n

$\hat{Q}$ is an estimator of the true (but unknown) ratio of the actual area of all units compared to corresponding visual estimates of the areas of all units. (The carat or "hat" over Q is used to indicate an estimated quantity.) Calibration ratios should be calculated on the basis of no less than 10 (i.e. $n \geq 10$) paired accurate measurements and visual estimates for each habitat unit type. That is, separate calibration ratios must be calculated for pools, riffles or other habitat unit types. Note that the number of paired accurate measurements and visual estimates for a given habitat type will depend on (a) the total number of units of that type, and (b) the sampling fraction for that habitat unit type. If a particular habitat unit type is quite rare, a much larger sampling fraction will be required to achieve the minimum sample size of 10 units than if a particular habitat unit type is quite common.

Visual estimates of habitat unit areas do not necessarily need to be "close to" the true (accurate measurements of) habitat unit areas, but it is important that visual estimates have a consistent relationship to true habitat unit areas. For example, if all visual estimates were exactly half of true areas, then it would be a simple (and accurate) matter to adjust all visual estimates by a calibration ratio of 2 to arrive at very accurate estimates of habitat unit areas.

It is advisable to plot the relationship between accurate measurements of habitat unit areas and corresponding visual estimates of areas in addition to calculating the calibration ratio.

Visual inspection of plotted data points may reveal outliers or coding errors that might not be otherwise noticed. Also, it is a good idea to check that the plotted data appear to pass through the origin. If plotted data do not appear to pass through the origin, then the formulas presented below may be seriously biased. (Alternative regression estimators should be used in that case, but they are not presented in this paper.)

Once the calibration ratio has been calculated and plotted data have been visually inspected, the total area of habitat for a given habitat unit type (M) can be estimated using

$$(2) \qquad \hat{M} = T_x \hat{Q}$$

where M = true total area of all units of a given type;

$T_x = \sum^{N} x_i$ = total of visual estimates of area for <u>all</u> units of a given type;

N = total number of units of a given habitat type

Equation (2) is a very natural and intuitive estimator, usually called a *ratio estimator*. Equation (2) states that the true total habitat area can be estimated as the product of (a) the total of the visual estimates and (b) the estimated ratio of true area to visual estimates of area.

A measure of the uncertainty of the estimated total area of a particular habitat type can be calculated from sample data using an estimator for the variance of equation (2). The variance of the estimated total, denoted by $V(\hat{M})$, can be estimated using

$$(3) \quad \hat{V}(\hat{M}) \approx \frac{N^2(N-n)}{Nn} \sum_{i=1}^{n} (m_i - \hat{Q}x_i)^2/(n-1)$$

Equation (3) is a large sample approximation for the variance of a ratio estimator and it may seriously underestimate the uncertainty of the estimated total habitat area if $n < 10$. For that reason, we recommend that $n \geq 10$.

Examination of equation (3) reveals that variance depends on two very different kinds of terms. First, variance (uncertainty) will be reduced simply as a function of sample size through the term (N-n)/Nn. As sample size, n, approaches the total number of units, N, clearly variance approaches zero. Thus, the sampling fraction (n/N) will influence variance. Second, the summation term essentially consists of squared differences between (a) true (accurate measurements of) habitat unit areas, m_i, and (b) predicted habitat unit areas, $\hat{Q}x_i$. If accurate estimates and visual estimates are highly correlated, and a plot of accurate estimates against visual estimates appears to pass through the origin, then

APPENDIX E

these squared differences will be small so that estimated variance will be small. In contrast, if visual estimates are inconsistently related to accurate measurements, then predictions of true habitat areas from visual estimates will be poor, squared differences will be large, and estimated variance will be large.

The strong dependence of estimator variance on a consistent relationship between true habitat unit areas and visual estimates of habitat areas makes it especially critical that observers follow a consistent technique in making their visual estimates. Carefully pacing off units at approximately 5 m increments requires substantial concentration and we recommend that our observers take periodic breaks to relax rather than making poor or inconsistent visual estimates of habitat areas. This requirement for consistency is also behind our recommendation that just a single observer be responsible for all visual estimates.

The total area of all units of all identified habitat types in a stream can be estimated simply by summing up individual estimates for individual habitat types (or individual habitat types within a particular reach of stream). Estimated variances are also additive because estimates of total habitat areas of particular habitat unit types are independent of one another (since they are based on entirely separate sample data).

Finally, approximate 95% confidence intervals for estimated total areas of habitat units can be constructed as

$$\hat{M} \pm 2 \cdot [\hat{V}(\hat{M})]^{0.5}$$

Table 1 presents results of application of this sampling design in a small Oregon coastal stream, Cummins Creek. In the Cummins Creek application, the stream was first stratified into a lower and a middle/upper reach. Sampling fractions were 10% (1 out of 10) in the lower reach and 5% (1 out of 20) in the middle/upper reach. Use of this method in Cummins Creek produced 95% confidence bounds for estimated total areas of pools and riffles that were about 13% and 16% of estimated totals, respectively.

E. Maps of habitat unit locations and sizes

Besides providing estimates of the total areas of particular habitat unit types, often with very small confidence intervals, this sampling design allows the construction of detailed maps of the locations and areas of all habitat units. Such maps could be used to compare habitat unit areas and sequences between seasons or years, or to evaluate the effects of various habitat alterations.

F. Costs

We estimate that it costs from $80 - $100 per mile to survey small basins using this technique. This cost estimate includes costs of (a) data collecttion, (b) computer data entry, and (c)

APPENDIX E

G. H. Reeves

Table 1. Total number of units (N) , number of units accurately measured (n), sample-based estimates of ratios of accurately measured areas to visually estimated areas ($\hat{Q}$), estimated total areas (m^2) of all units ($\hat{M}$), estimated variances for estimated total areas ($\hat{V}(\hat{M})$), and 95% confidence bounds for estimated total areas (95% C. I.) for pools and riffles in lower, middle/upper, and all reaches combined of Cummins Creek during July 1985. Visual estimates of habitat unit areas were made for all units.
(from: Hankin and Reeves 1988)

Pools

Reach	N	n	$\hat{Q}$	$\hat{M}$	$\hat{V}(\hat{M})$	95% C. I.
Lower	65	7	0.990	6,141	119,827	± 875
Middle/ Upper	134	6	1.029	8,284	448,315	± 1,721
All Reaches				14,425	568,142	± 1,938

Riffles

Reach	N	n	$\hat{Q}$	$\hat{M}$	$\hat{V}(\hat{M})$	95% C. I.
Lower	62	6	1.066	12,556	159,155	± 1,026
Middle/ Upper	124	7	0.926	19,208	3,846,554	± 4,799
All Reaches				31,764	4,005,709	± 5,146

data analysis. The cost will of course vary with crew experience, basin size, and the number of habitat unit types identified. In most systems, an experienced crew can cover 4-6 stream miles per day. Interestingly, larger systems may often be covered more quickly than smaller systems because habitat units are larger so that there are fewer per stream mile. Finally, the general requirement that sample sizes exceed 10 for each distinct habitat unit type means that large numbers of distinct habitat unit types will require a large number of accurate (and more costly) measurements of habitat areas.

G. Review of Procedures (* denotes optional procedure)

(1) Prior to field work:

a. Determine the types of habitat units that are to be identified.
b. Determine habitat unit characteristics that are to be measured or estimated at each unit.
c. Determine sampling fractions (1/k) for each habitat unit type (this will determine the number of units for which both accurate and visual estimates of habitat unit area are made).
d. Given prespecified values for k, which may differ between habitat unit types, choose independent random starts on the interval 1 through k for each distinct habitat unit type.
*e. If necessary or desirable, stratify basin into different areas or reaches on the basis of stream gradient or other distinctive feature(s). These different areas or reaches will constitute distinct location strata and should each be independently sampled.

(2) Field work:
a. Observer begins at first habitat unit, identifies its type, and collects necessary data. Observer makes visual estimate of habitat unit area for every identified habitat unit. Points of reference are noted by data recorder.
b. At the unit selected by the random start within each identified habitat type, and at every k units thereafter, the observer makes a visual estimate of habitat unit area, and the two person team makes an accurate estimate of habitat unit area.
*c. If necessary, observer marks units which are to be later sampled for fish. Units should be marked with highly visible flagging at the upstream and downstream ends of these units and flagging should have unit type and unit number written on it.

(3) Data entry and analysis:
a. Data are entered into spreadsheet in the natural order in which units were encountered in field work.

APPENDIX E

b. Distinct calibration ratios are calculated for each identified habitat unit type using equation (1).
c. Totals areas, associated variances and confidence intervals are calculated for each identified habitat unit type using equations (2) and (3).

III. Estimating the total number of fish

A. Selection of units

It is obviously impractical to estimate the total number of fish by sampling every stream habitat unit. Instead, we recommend selection of a systematic sample of habitat units (from within each habitat type), following those procedures presented for selection of units for accurate measurements in part II.B. Systematic selection of units does not require a preexisting map of the locations of all habitat units nor does it require knowledge of the total number of units of each habitat type. In additional, systematic samples will ensure that sample data are collected along the entire longitudinal gradient of the basin. As for units selected for accurate measurements of habitat areas, sampling within each distinct habitat unit type must begin with an independent random start.

The fraction of the units that are sampled need not be the same for every habitat type and may depend on unit type, fish species and habitat preferences as well as available time, funds and personnel. It is usually, but not always, best to have higher sampling fractions for those habitat types that appear to be preferred by the species of interest. For example, if the species of interest were 1+ juvenile steelhead trout or coho salmon, then pools should probably have a higher sampling fraction than riffles or glides. In this case one might sample 25% of all pools, 15% of all glides and just 10% of all riffles. It is extremely important to remember that all habitat unit types must be sampled even if fish are not "believed" present in some habitat types. There is only one method by which their absence in that habitat type may be verified: collection of sample data for that habitat type.

Units which are to be sampled for fish should have been previously marked by the two person team responsible for physical habitat measurements. Plastic flagging or other markers with unit type and number should have been placed at the upper and lower boundaries of selected units. If visual counts of fish are to be made by divers in selected units, then it is best to have a minimum of two hours between the time the units are marked and when they are actually snorkled. This delay should be sufficient to minimize any effects of disturbance on fish in habitat units.

APPENDIX E

B. Sampling fish populations

Estimation of fish numbers relies on essentially the same premise as estimation of habitat areas. If divers count a fairly consistent fraction of fish actually present in habitat units, then there should be a strong correlation between diver counts and the "true" (accurate estimates of) numbers of fish present. In this case visual estimates are made by divers using mask and snorkel and "accurate" estimates are made using a multiple pass electrofishing removal method estimator. By calculating a calibration ratio relating these accurate estimates to diver counts, based on a small sample of units in which both visual estimates and accurate estimates are made, one may "adjust" diver counts to estimates of true abundance in those units in which only visual estimates are made.

A team of two divers is used to count fish. Divers enter the water downstream from the selected unit and proceed slowly upstream. The divers position themselves near the midline of the unit and move parallel to one another using hand signals to coordinate their movements. Observed fish are identified to species or species/age class and counted. Fish counts are recorded with a lead pencil on a plexiglass slate that has had the surface roughened with sandpaper. Observations should all be made during times of day when visibility is best, generally between 0900 and 1700.

Correlations between diver counts and accurate estimates will generally vary with species, age-class and habitat type. For example, we found higher correlations between diver counts and accurate estimates for coho salmon in pools than for 1+ steelhead trout in pools (Hankin and Reeves 1988). These differences were attributable to differences between the two species in microhabitat distribution and behavioral responses to divers. Trout were closely associated with the bottom, whereas coho salamon were more surface-oriented and were thus easier to see. Trout were also more "skitterish" and sought cover more quickly than salmon, especially in smaller units. Because of these differences, divers scanned the bottom immediately upon entering units and counted trout before salmon.

Use of snorkeling to count fish has obvious limitations which may make it impractical for use in some situations. Water clarity is critical, the method is most effective in small streams, and there are generally limited numbers of individuals who are highly trained and skilled in this method of observation. We are currently exploring alternatives to snorkeling, but we have not yet developed any sound alternatives.

Of those units in which diver counts of fish numbers are made, we select a random subsample within which both diver counts and more accurate estimates are made. The theory of this method requires that the "accurate" estimates of fish abundance be equal to the "true" but unknown numbers of fish present. It is therefore extremely important that accurate methods produce

APPENDIX E

estimates of fish numbers that have very small confidence intervals.

C. Data entry and storage

Data on diver counts and accurate estimates made for selected units can be entered in the spreadsheet format in the same manner as those for physical habitat measurements. Additional computer programs may be necessary for estimation of population size for the "accurate" estimation method, however.

D. Calculations and formulas

A "calibration ratio" establishing the correspondence between accurate estimates (true numbers) of fish present, y_j, and diver counts, d_j, within a given habitat type may be calculated using

$$(4) \quad \hat{R} = \left(\sum_{J=1}^{n'} y_j\right) / \left(\sum_{J=1}^{n'} d_j\right)$$

where: y_j = true number of fish in unit j; $j = 1,2,\ldots,n'$ (estimated by use of a very accurate method);

d_j = mean count of fish by two divers in unit j;

n' = number of units in which both diver counts and accurate estimates are made.

As for estimation of habitat areas, distinct calibration ratios must be calculated for each habitat type and there should be a minimum of ten units within each habitat type for which both diver counts and accurate estimates are made (i.e. $n' \geq 10$).

Ideally, the units selected for accurate estimates in addition to diver counts should be a simple random or systematic subsample of those units in which diver counts are made. Occasionally, however, it may prove impractical or impossible to carry electrofishing equipment into some selected units. In that event, units reflecting the full range of size and complexity of those units found in the system should be included in the sample of size n'.

For units in which only diver counts have been made, the calculated "calibration ratio" allows adjustment of diver counts to give a better estimate of the true number of fish actually present. (Divers may only count half the fish that are actually present, for example, in which case the true calibration ratio would be 2.) The numbers of fish present in such units can therefore be estimated as the product of the mean diver count and the estimated calibration ratio using

APPENDIX E

(5) $\hat{y}_i = \hat{R}d_i$

where: $\hat{R}$ = calculated calibration ratio (equation (4);

d_i = mean of two diver counts in unit i.

If the total number of units in which diver counts are made is defined as n, and the total number of units in which both diver counts and accurate estimates are made is defined as n', then there will in general be (n-n') units in which fish numbers will be estimated using equation (5). In the remaining n' units, the "accurate" method of estimating fish numbers eliminates the need to use equation (5); the accurate estimates should be used for these units.

Finally, the total number of fish present in all units of a given habitat type may be estimated using

(6) $\hat{Y} = N \sum_{i=1}^{n} \hat{y}_i/n$

where: Y = (true) total number of fish in all units of a given habitat type;

N = total number of units of a given habitat type;

n = total number of units in which diver counts are made; i = 1,2,...,n.

Equation (6) is simple and intuitive. It basically consists of multiplying the mean estimated number of fish per habitat unit (= $\Sigma\hat{y}_i/n$) by the total number of habitat units (= N).

In some streams, the number of fish present in habitat units may be highly correlated with the sizes of habitat units. In that case, equation (6) will not give the best estimate of total fish abundance. Hankin (1984, 1986) discusses alternative estimators that will perform better than equation (6) if fish numbers are highly correlated with habitat unit sizes.

A measure of uncertainty for the estimated total number of fish in a given habitat type may be calculated using the following estimator for the variance of equation (6):

(7) $\hat{V}(\hat{Y}) = \frac{N(N-n)}{n(n-1)} \sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2 + \frac{N}{n} \sum_{i=1}^{n} \hat{V}(\hat{y}_i)$

APPENDIX E

where: N = total number of units of a given habitat type
n = total number of units in which diver counts are made

$\hat{y}_i$ = estimated number of fish in unit i; $i = 1,2,..,n$

$\bar{y} = \sum^{n} \hat{y}_i/n$ = mean estimated number of fish per habitat unit.

and $\hat{V}(\hat{y}_i)$ = estimated variance of the estimated number of fish in unit i

$\hat{V}(\hat{y}_i)$ represents errors of estimation of fish numbers in individual habitat units. It may be assumed equal to zero for those units in which very accurate estimates are made or, alternatively, may be calculated on the basis of formulas appropriate for removal method estimation using electrofishing. (Remember that there are n' out of n units in which the accurate estimates have been made.)

For those units in which <u>only</u> diver counts are made (there are $n-n'$ such units), $\hat{V}(\hat{y}_i)$ will depend on (a) variation between the two diver counts made in those units and (b) variance of the estimated calibration ratio relating accurate estimates to diver counts.

Between diver variance is denoted by $\hat{V}(d_i)$ and is estimated using

(8) $$\hat{V}(d_i) = ½ \sum_{k=1}^{2} (d_{ik} - d_i)^2$$

where: d_{ik} = count of fish by diver k in unit i; $k = 1,2$

$d_i = \sum_{k=1}^{2} d_{ik}/2$ = mean diver count in unit i

i = unit in n but <u>not</u> in n'

Variance of the estimated calibration ratio is calculated using

(9) $$\hat{V}(\hat{R}) = \frac{(N-n')}{Nn' \bar{d}^2} \sum^{n'} (\hat{y}_i - \hat{R}d_i)_2/(n'-1)$$

where: $\bar{d} = \sum^{n'} d_i/n'$ = "grand mean" diver count

APPENDIX E

Note that the summation in equation (10) is over the n' units for which paired diver counts and accurate estimates were made.

Finally, for those (n-n') units in which only diver counts have been made, variance of the estimated number of fish in such units can be calculated using

$$(10) \qquad \hat{V}(\hat{y}_i) = \hat{R}^2\hat{V}(d_i) + d_i\hat{V}(\hat{R}) - \hat{V}(d_i)\hat{V}(\hat{R})$$

These values would then be substituted in equation (7), above.

Although of complicated forms, the above formulas for calculating the variance of an estimated total number of fish in a given habitat type can be separated into two distinct parts. One component of variance arises due to what statisticians term first stage variance. If there were no errors of estimation of fish numbers within selected habitat units, but only a sample of n habitat units were selected from a total of N habitat units, there would be errors of extrapolation from the sample units to all of the units. These errors result from variation in the true numbers of fish between habitat units. If, for example, each unit had exactly the same number of fish, then there would be no variation in fish numbers between units and, as a result, first stage variance would equal zero. In contrast, if true fish numbers were highly variable across habitat units, then first stage variance would be large.

Most fishery biologists are not very familiar with the concept of first stage variance, but they are very familiar with what statisticians term second stage variance. Second stage variance reflects errors of estimation of fish numbers within selected units. If every habitat unit were sampled, then all of the errors of estimation would come from this stage of sampling since no extrapolation would be involved. Mark-recapture or removal method estimators of population size will in general result in smaller second stage variance than "calibration" of diver counts.

In our experience with sampling streams, first stage variance usually is a much more important source of error of estimation than is second stage variance. Also, if numbers of fish present in habitat units are poorly correlated with the sizes of habitat units, then first stage variance can only be reduced by sampling a large fraction of all habitat units. The use of divers for visual estimates of fish numbers in habitat units allows one to greatly increase the total number of units that are sampled for fish. Although this usually results in slightly greater errors of estimation of fish numbers within units (second stage variance), the substantial reduction in first stage variance that results more than compensates for these minor additional errors. To put it more simply, one makes a modest sacrifice of accuracy within individual habitat units to obtain a dramatic increase in accuracy of estimation of fish numbers in all habitat units.

APPENDIX E

Table 2 illustrates the results of applying these methods for estimation of juvenile coho salmon and 1+ steelhead trout numbers in pools and riffles of Cummins Creek. Diver counts were made in approximately 20% of all units and paired diver counts and exhaustive electrofishing/removal method estimates were made in about 8 units of each habitat type. Confidence bounds (not reported on Table 2) for the total abundance of salmon and trout in all pool and riffle units combined were approximately 22% and 17% of the estimated totals, respectively.

E. Costs

We have not determined the average costs of sampling fish populations using this sampling design. However, we have compared the probable performance of this design with a more typical stream survey that might be carried out exclusively using electrofishing methods for estimation of fish numbers in selected habitat units (Hankin and Reeves 1988). For the same total cost of sampling, we found that our visual estimation survey (with calibration) would result in variances that were from 1.7 to 3.3 times smaller than those that would be achieved in the more standard survey (electrofishing only). That is, for the same total survey cost, the visual estimation design was from 1.7 to 3.3 times as cost-effective. For the typical survey, fewer units can be sampled if only electrofishing is used to estimate fish numbers in selected habitat units. Although diver counts may be less accurate than electrofishing, divers can count fish much more rapidly and can therefore examine a much larger number of habitat units. This increased coverage of habitat units in turn leads to a substantial reduction in first stage variance and in total errors of estimation.

F. Review of procedures (* denotes optional procedure)

(1) Before field work:

a. Determine types of habitat units that are to be identified.

b. Determine sampling fractions for visual estimates of fish numbers for each habitat unit type. (These may differ with habitat unit type.) Select independent random starts for each habitat unit type. Units selected by these random starts should be marked by the team collecting physical data (Part II) as should subsequent units that appear in systematic samples drawn from each habitat type.

c. Determine approximate subsampling fraction for which both visual estimates and accurate estimates will be made. Select appropriate random starts for selection of these units from those selected and marked in (1)b.

*d. If necessary or desirable, stratify basin into different areas of reaches on the basis of gradient changes or other distinctive features.

APPENDIX E

G. H. Reeves

Table 2: Estimated abundances ($\hat{Y}$) of 1+ steelhead trout and juvenile coho salmon, total number of habitat units (N), sample sizes for diver counts (n), and estimated variances of abundance estimates ($\hat{V}(\hat{Y})$) in lower, middle and upper pools and riffles and in all pools, all riffles and all pools and riffles, in Cummins Creek, July, 1985. (from: Hankin and Reeves 1988).

Habitat Type/ Location Stratum	N	n	Coho Salmon $\hat{Y}$	Coho Salmon $\hat{V}(\hat{Y})$	Steelhead Trout $\hat{Y}$	Steelhead Trout $\hat{V}(\hat{Y})$
Lower pools	65	11	2,111	112,769	1,480	21,185
Middle pools	67	13	1,088	36,024	738	17,205
Upper pools	67	12	101	1,266	428	13,943
All pools			3,300	150,059	2,646	52,333
Lower riffles	62	10	576	40,407	527	24,505
Middle riffles	67	13	230	5,588	236	4,967
Upper riffles	57	9	0	0	0	0
All riffles			806	45,995	763	29,472
All pools and all riffles			4,106	196,054	3,409	81,805

APPENDIX E

(2) Field work
  a. Divers proceed to unit selected as random start for each habitat type and count fish numbers in that unit and in subsequent units that appear in systematic samples. Record unit numbers and fish counts (individually) on data sheets as appropriate.
  b. For units selected in (1)c above, use a multiple pass electrofishing removal method estimator to obtain an accurate estimate of true fish numbers in these units. (Diver counts are <u>also</u> made in these units).

(3) Data entry and analysis
  a. Enter collected data in spreadsheet as for physical habitat data.
  b. Calculate calibration ratios for each distinct habitat unit type, using equation (4).
  c. Estimate true numbers of fish present in those units for which only diver counts are available using equation (5).
  d. Estimate the total number of fish in all units of a given habitat type using equation (6).
  e. Calcuate variance estimates using equations (7) - (10).

APPENDIX E

IV. Literature Cited

Bisson, P.A., J.L. Nielson, R.A. Palmason, and L.E. Grove. 1981. A system for mapping habitat types in small streams, with examples of habitat utilization by salmonids during low stream flow. p. 62-73. In: N.B. Armantrout (Ed.). Aquisition and utilization of aquatic habitat. Western Div. Amer. Fish. Soc., Portland, OR. 376 p.

Bisson, P.A. 1988. The importance of identifying limiting factors. in press. In: J. W. Buell (Ed.). Proceedings of the stream habitat enhancement evaluation workshop. October, 1986. Portland, OR. U.S. Dept. of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Portland, OR.

Everest, F.H. and 5 co-authors. 1986. Abundance, behavior, and habitat utilization by coho salmon and steelhead trout in Fish Creek, Oregon as influenced by habitat enhancement. Annual report 1985. U.S. Dept. of Energy, Bonneville Power Administration, Division of Fish and Wildlife. Portland, OR. 100 p.

Habitat Inventory Committee, Western Division American Fisheries Society. 1985. Aquatic Inventory: Glossary and Standard Methods. Western Division American Fisheries Society. 34 p.

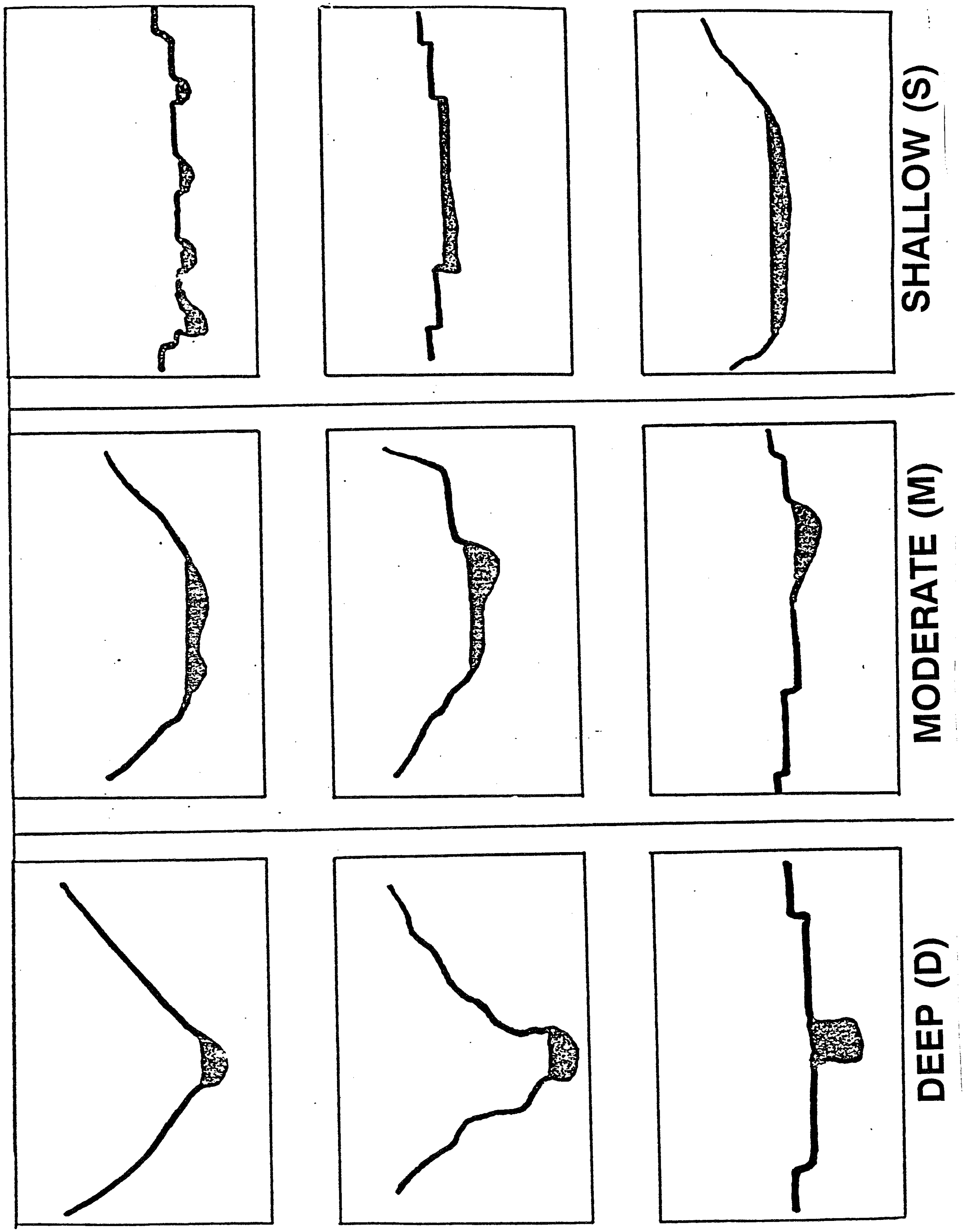
Hankin, D.G. 1984. Multistage sampling designs in fisheries research: applications in small streams. Can. J. Fish. Aquat. Sci. 41: 1575-1591.

Hankin, D.G. 1986. Sampling designs for estimating the total number of fish in small streams. Res. Pap. PNW-360. U.S.D.A. Forest Service, Pacific Northwest Research Station. Portland, OR. 33 p.

Hankin, D.G. and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Can. J. Fish. Aq. Sci. 45: in press.

APPENDIX F

ENTRENCHMENT



APPENDIX G

AQUATIC HABITAT INVENTORY GLOSSARY

Cover: Anything that provides protection from predators or ameliorates adverse conditions of streamflow and/or seasonal changes in metabolic costs. May be instream cover, turbulence, and/or overhead cover, and may be for the purposes of escape, feeding, hiding, or resting. For use in Stream Inventory, count turbulence cover as only that area of turbulence,; for cover, vegetation of other material must be within 10 inches of the surface.

Embeddedness: The degree that larger particles (boulders, rubble, or gravel) are surrounded or covered by fine sediment. Usually measured in classes according to the percentage of coverage of larger particles fine sediments.

Glide: A portion of stream flowing smoothly and gently, with moderately low velocities (10-20cm/sec), and little or no surface turbulence. The longitudinal profile of the feature will be level, or slightly sloped downstream. No hydraulic control present.

Pool: (a) A portion of the stream with reduced current velocity, often with water deeper than the surrounding areas, and which is frequently usable by fish for resting and cover. (b) A small body of standing water, e.g. in a marsh or on the flood plain. May at times contain surface turbulence, but always has a hydraulic control present on the downstream end of the feature.

Reach: (a) Any specified length of stream. (b) A relatively homogeneous section of stream having a repetitious sequence of physical characteristics and habitat types. (c) A regime of hydraulic units whose overall profile is different from another reach.

> Specific Reach: A length of channel uniform with respect to selected habitat characteristics or elements (discharge, depth, area, slope, population of hydraulic units), fish species composition, water quality, and type and condition of bank cover.

Riffle: A shallow rapids where the water flows swiftly over completely or partially submerged obstructions to produce surface agitation, but standing waves are absent.

Stream Order: See accompanying Appendix A for illustration.

Stream Bank: The portion of the channel cross section that restricts lateral movement of water at normal water levels. The bank often has a gradient steeper that 45 degrees and exhibits a district break in slope from the stream bottom. An obvious change in substrate may be a reliable delineation of the bank.

> Lower Bank: The periodically submerged portion of the channel cross section from the normal high water line to the water's edge during the summer low flow period.

> Upper Bank: That portion of the topographic cross section from the break in the general slope of the surrounding land to the normal high water line.

Riparian Vegetation: Vegetation growing on or near the banks of a stream or body of water on soils that exhibit some wetness characteristics during some portion of the growing season.

APPENDIX G

<u>Hydraulic Control</u>: The top of an obstruction to which stream flow must rise before passing over, or a point in the stream where the flow is constricted.

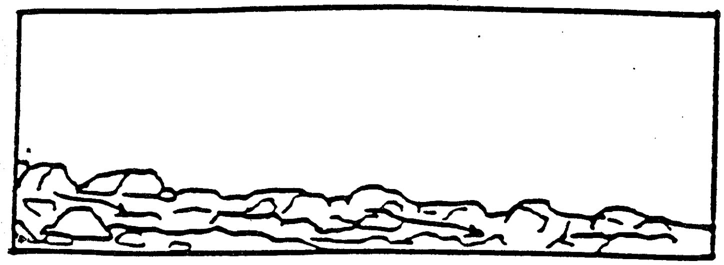
<u>Riparian Area</u>: The area between a stream or other body of water and the adjacent upland identified by soil characteristics and distinctive vegetation. It includes wetlands and those portions of flood plains and valley bottoms that support riparian vegetation.

<u>Side Channel</u>: Lateral channel with an axis of flow roughly parallel to the mainstem and which is fed by water from mainstem; a braid of river with flow appreciably lower than the main channel, or in poorly defined watercourses flowing through partially submerged gravel bars and islands along the margins of the mainstem.

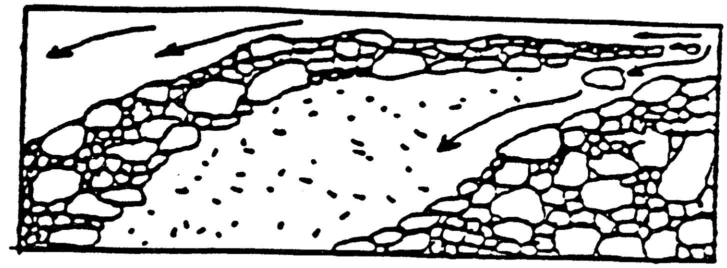
<u>Sinuosity</u>: (a) The ratio of channel length between two points on a channel to the straight distance between the same two points. (b) The ratio of channel length to down valley length. Channels with sinuosities of 1.5 or more are called meandering.

<u>Turbulence</u>: The motion of water where local velocities fluctuate and the direction of flow changes abruptly and frequently at any particular location, resulting in disruption of laminar flow. It causes surface disturbance and uneven surface level, and often masks subsurface areas because air bubbles are entrained in the water.

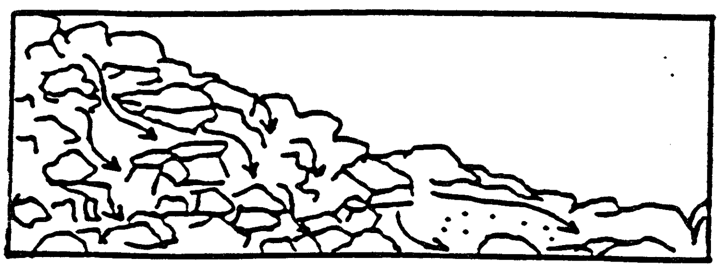
APPENDIX G



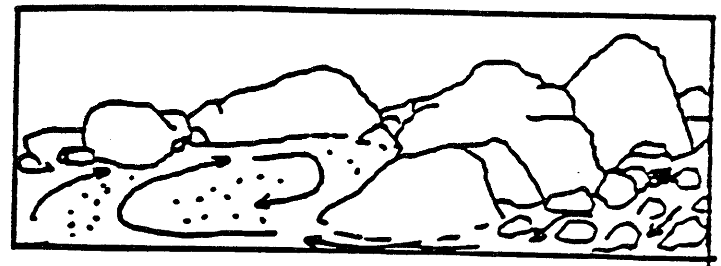
Riffle



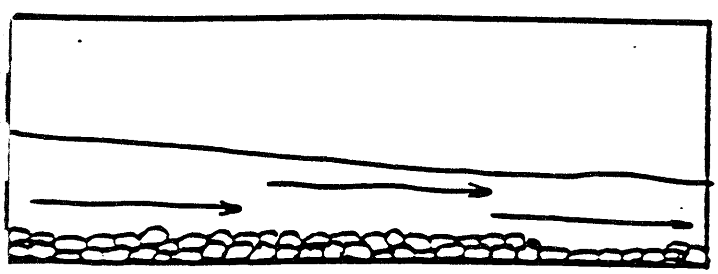
Side Channel



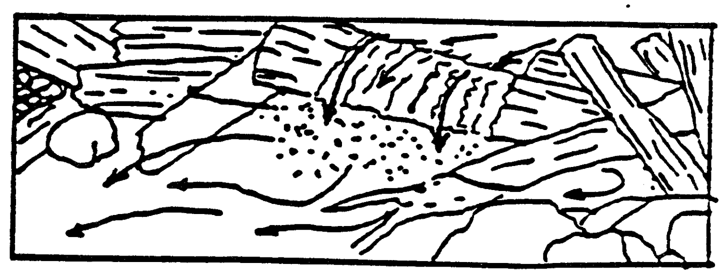
Riffle



Pool



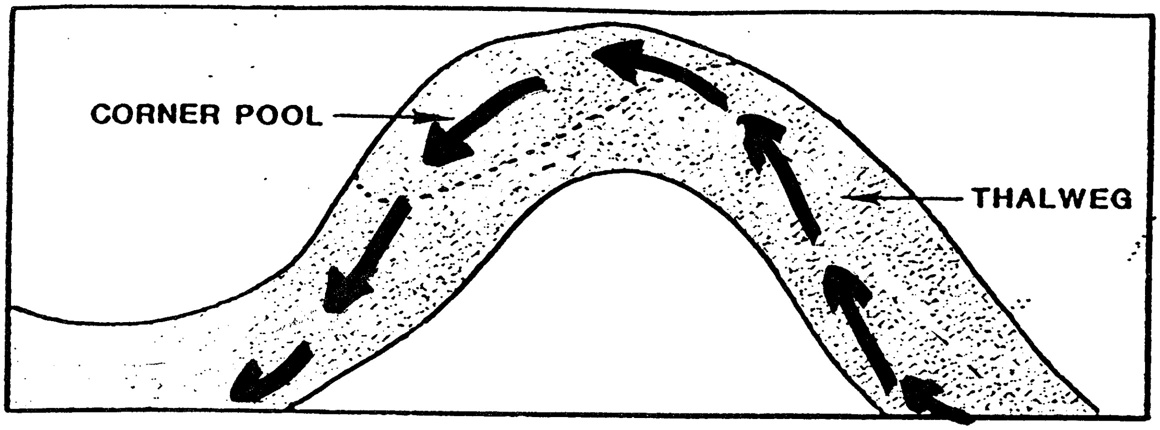
Glide



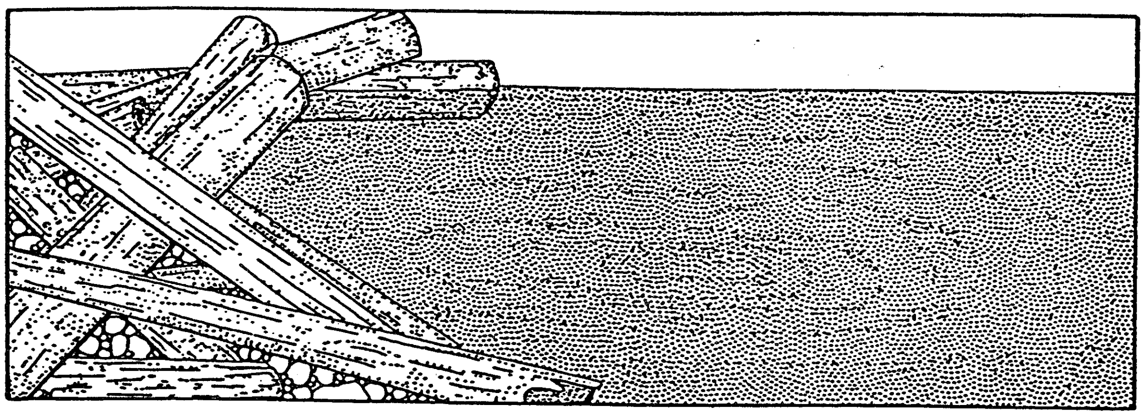
Pool

Fundamental habitat units used to describe habitat condition (from Bisson et al. 1982).

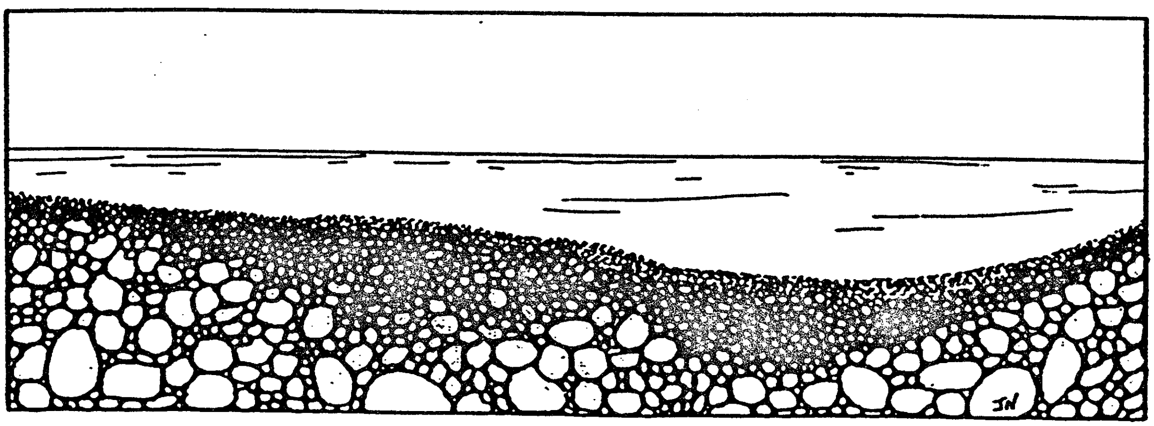
APPENDIX G



A lateral scour pool resulting from a shift in channel direction.



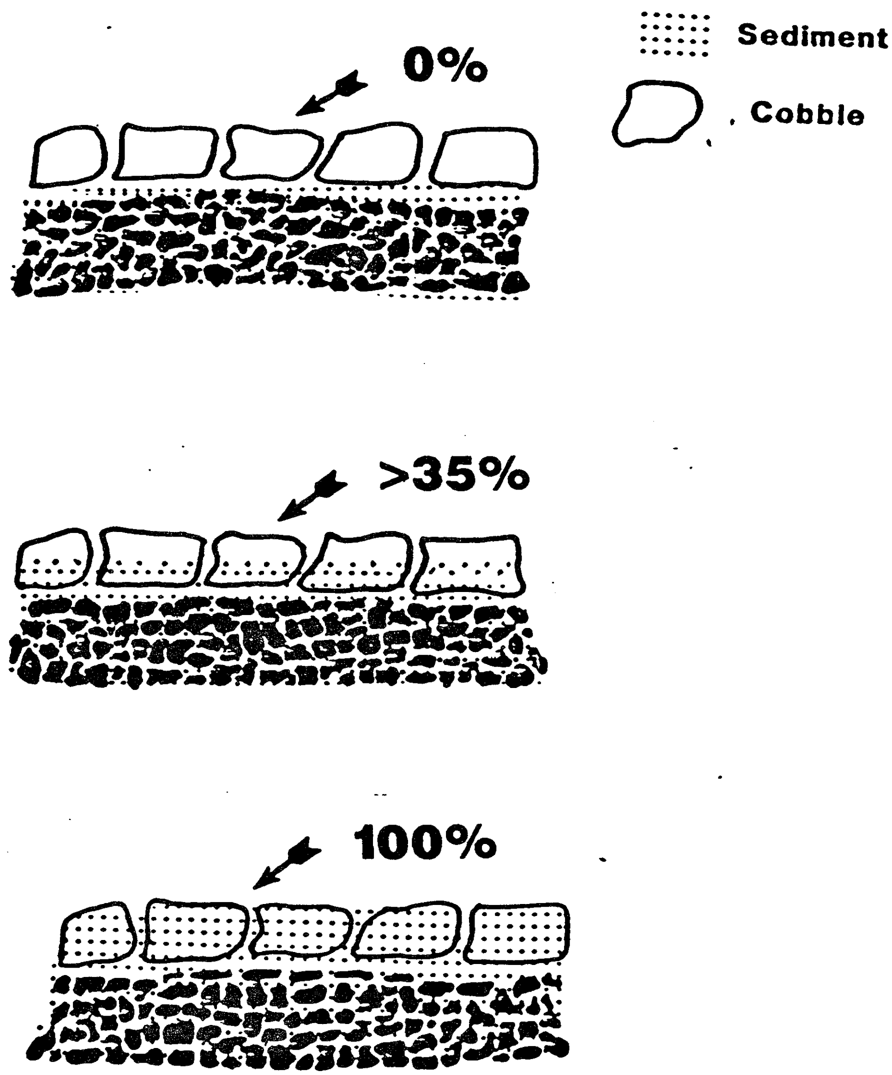
Water impounded upstream from a complete or nearly complete channel blockage, typically caused by a log jam, beaver dam, rockslide, or stream habitat improvement device (boulder berm, gabion, log sill, etc.)



A wide shallow pool of low turbulence. Sometimes used synonymously with glide.

APPENDIX H

EXAMPLE: GRAPHIC REPRESENTATION OF COBBLE EMBEDDEDNESS

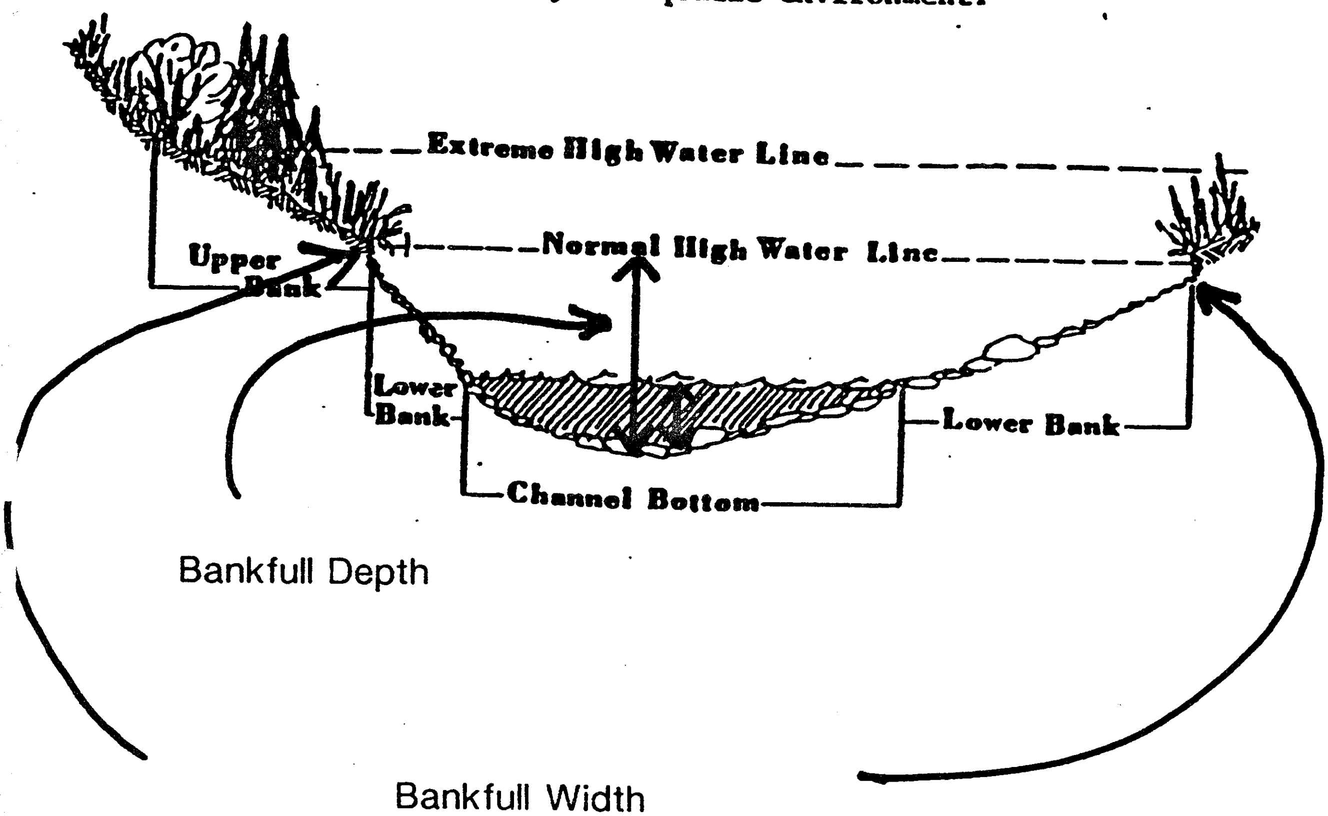


APPENDIX I

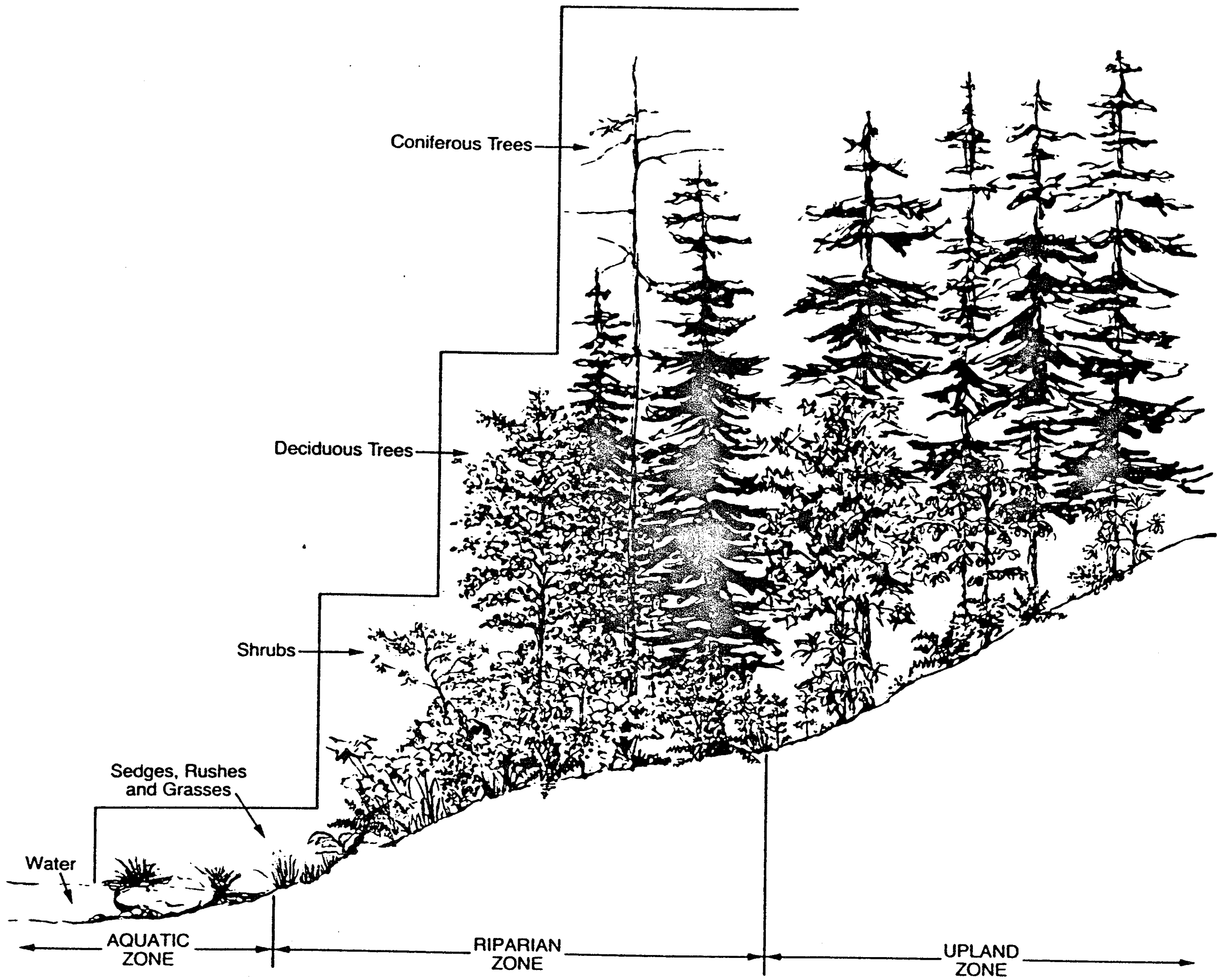
<u>Upper Bank</u> - That portion of the topographic cross section from the break in the general slope of the surrounding land to the normal high water line. Terrestrial plants and animals normally inhabit this area.

<u>Lower Banks</u> - The intermittently submerged portion of the channel cross section from the normal high water line to the water's edge during the summer low flow period.

<u>Channel Bottom</u> - The submerged portion of the channel cross section which is totally an aquatic environment.



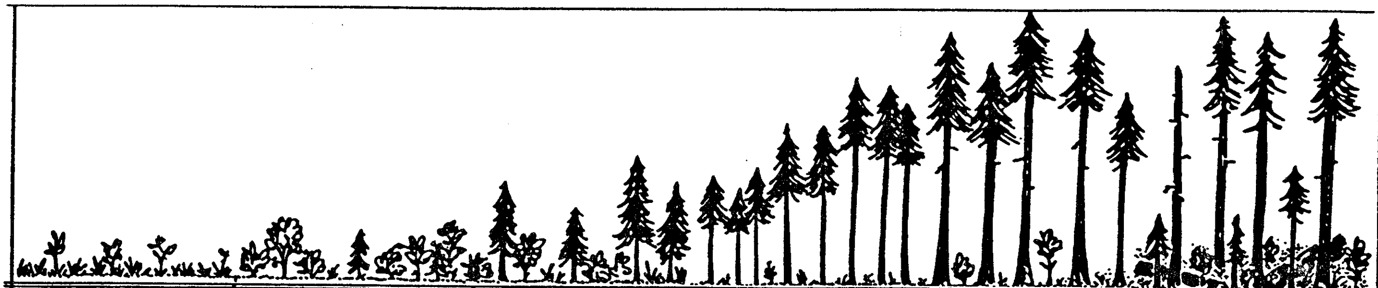
APPENDIX I



—Riparian zones have vegetation that requires large amounts of free or unbound water and are transitional between aquatic and upland zones.

APPENDIX J

Successional Pattern of Stand Conditions



Grass/Forb	Shrub/ Seedlings	Pole/Sapling	Small Trees	Large Sawtimber, Large Trees	Old-growth

Approximate stand age (years)
0 5 15 30 80 200 700

	Height Class 1: < 2' 2: 2'-5' 3: 5'-10' 4: > 10'	Size: < 8"	Size: 8"-20.9"	Size: 21"-32"	Size > 32"
GF	**SS**	**SP**	**ST**	**LT**	**MT**

Code:

GF = Grass/Forb Condition:
The grass-forb stand condition lasts 2-5 years and occasionally as long as 10 years. Shrubs and some trees that sprout are not yet dominant.

SS = Shrub/Seedling Condition:
The shrub stand condition often lasts 3-10 years but may remain for 20-30 years if tree generation is delayed. Tree regeneration may be common, but trees are generally less than 10 feet tall and provide less than 30 percent of crown cover.

SP = Sapling, Pole Condition:
The open sapling-pole condition occurs when trees exceed 10 feet in height and are less than 8 inches in dbh.

ST = Small Tree Condition:
The pole condition has very little ground vegetation because of closed crown canopy. Average stand d.b.h. is 8 inches to 20.9 inches.

LT = Mature Stand Condition:
The mature condition is characterized by trees with and average d.b.h. of 21 inches to 32 inches d.b.h.

MT = Old-growth Condition:
Old-growth stand conditions are characterized by decadence of live trees, snags, down woody material, and replacement of some of the long-lived pioneer species such as Douglas-fir by climax species such as western hemlock. Stands often have two or more layers with large diameter overstory trees commonly older than 200 years. Size is generally greater than 32 inches in d.b.h.

APPENDIX J

SPECIES CODES FOR CONIFER AND HARDWOOD SERAL STAGES

C	**Conifer Forest**
CA	Subalpine fir, mountain hemlock, whitebark pine open parks
CC	Cedar, Western Red
CD	Douglas-fir
CE	Subalpine fir - engelmann spruce closed forest (not parks)...
CF	Fir, silver and noble
CH	Hemlock, western
CJ	Juniper
CL	Lodgepole pine, shore pine (climax or stable seral)
CM	Mountain hemlock
CP	Ponderosa pine, jeffery pine
CQ	Western white pine
CR	Red fir (Shasta red)
CS	Spruce, sitka
CT	Port Orford cedar
CW	White fir, grand fir

H	**Hardwood Forest**
HA	Alder
HB	Bigleaf maple
HC	Cottonwood, as, bottom land, overflow bottom land
HL	Liveoak, canyon
HM	Madrone
HO	Oak, Oregon White, California black
HQ	Quaking Aspen
HT	Tanoak